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CR 160909

## 3 CABIN FIRE SIMULATOR LAVATORY TESTS

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#### PREFACE

The objective of this program has been to compare the effect of airline trash fires in lavatories constructed of contemporary and improved materials.

All tests in this program were conducted in the Douglas Cabin Fire Simulator (CFS) under in-flight ventilation conditions. All tests were allowed to continue for a period of 1 hour. Data obtained during these tests included:

- Heat flux and temperatures of the lavatory
- Cabin temperature variations
- ullet Gas analyses for  $oldsymbol{0}_2$ ,  $oldsymbol{C0}_2$ ,  $oldsymbol{C0}_2$ ,  $oldsymbol{CH}_4$ ,  $oldsymbol{HF}$ ,  $oldsymbol{HC1}$ , and  $oldsymbol{HCN}$
- Respiration and electrocardiogram data on instrumented animal subjects (rats) exposed in the cabin
- Color motion pictures.

All tests resulted in a survivable cabin condition; however, occupants of the cabin would have been subjected to noxious fumes.

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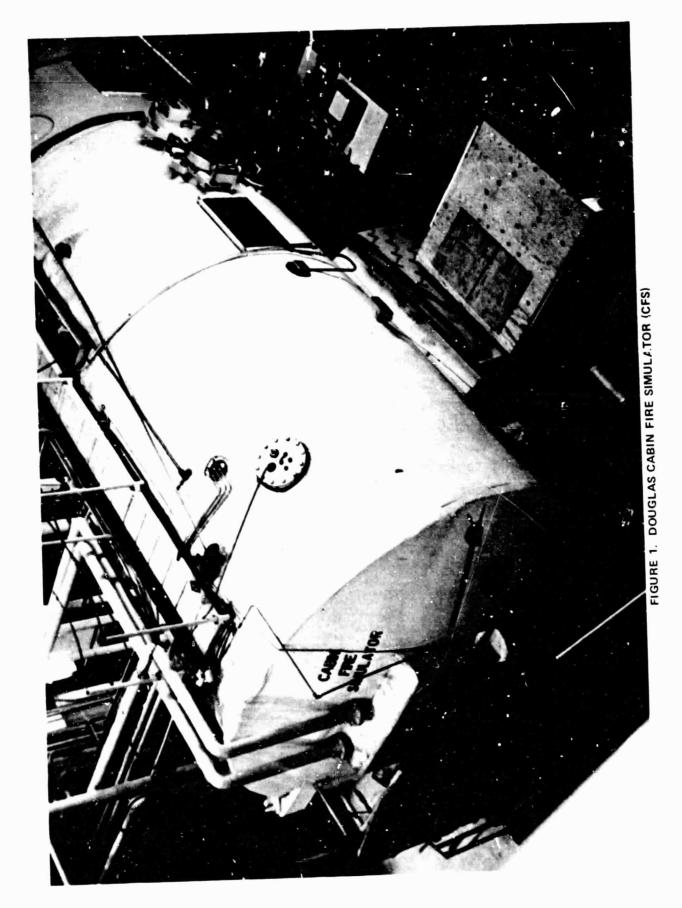
#### INTRODUCTION

Aircraft lavatories inherently contain combustible products, have high ventilation rates, and are utilized for temporary storage of trash. They are a closed compartment where fires can develop undetected. Therefore, lavatories are prime candidates for fire safety improvement.

Airline trash storage is the greatest lavatory fire source. A previous phase of this program tested various quantities and types of trash fires to determine the fire source configuration for this program (Reference 5).

This report identifies the thermal, environmental, and biological hazards of airline trash fires within simulated aircraft lavatories. Lavatories were constructed of contemporary and improved materials. Two improved lavatory constructions were tested and the results were compared to previous tests of a contemporary baseline lavatory. To further evaluate the thermal damage and propagation of lavatory fires, interior contemporary panels commonly found adjacent to the lavatory were included for each test configuration.

This test program was conducted in the Douglas Cabin Fire Simulator (CFS), see Figure 1. This report presents the test results and summarizes the conclusions.



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#### TEST ARTICLES

The two types of improved lavatory constructions tested were designated Module A and Module B. Module A panels were constructed by DECO in Fountain Valley, California. Module B panels were constructed by Boeing Commercial Aircraft Company located in Renton, Washington.

The basic construction of the test panels was Nomex honeycomb core with fiber-glass facing and backing impregnated with phenolic resin. Polyimide foam-filled core and polyvinylidene fluoride decorative were used for all Module A panels, while polyvinyl fluoride decorative was used for all Module B panels. Some of the Module B panels were filled with phenolic foam. Rigid fire-resistant polyurethane foam was used for Module B panel edge closeout. Panel constructions are shown below.

#### **MODULE A PANEL CONSTRUCTION**

	KYNOL DECORATIVE (POLYVINYLIDENE FLUORIDE)
	DECO XMP100 FIBERGLASS
	NOMEX HONEYCOMB CORE SOLAR POLYIMIDE FOAM-FILLED
	DECO XMP100 FIBERGLASS
MODULE B PANEL CONST	RUCTION
	TEDLAR DECORATIVE (POLYVINYL FLUORIDE)
	CIBA GEIGY FIBERGLASS (PHENOLIC RESIN)
	NOMEX HONEYCOMB CORE — PHENOLIC FOAM-FILLED

#### CFS CONFIGURATION AND INSTRUMENTATION

The CFS was configured and instrumented as shown in Figure 2, with a metal ceiling tangent to the cabin air distribution duct outlet located on the centerline of the cabin. Cabin air was exhausted at 26,900 liters per minute (950 °CFM) from two ducts at floor level that extended the full length of the cabin. The test modules were instrumented as shown in Figure 3.

#### BIOLOGICAL EXPERIMENT

Animal subjects (rats) were instrumented for heart beat and respiration using an electrode belt containing two electrocardiogram electrodes and a respiration sensor. The experiment was conducted using the method developed under Contract NAS 2-8668 for NASA Ames Research Center (Reference 1). A cage containing an animal subject (Figure 4) was placed on a portable stand at a height of 10.2 cm (4 ft) above the floor, at a distance of 10.2 cm (4 ft) from the door of the lavatory, and at an angle of approximately 30 degrees from the hinged side of the door. The cage was shielded from direct heat radiating from the lavatory with Fiberfrax which covered the top of the cage as well as the two sides nearest the lavatory. The remaining sides were open to the cabin atmosphere. The subject's electrode belt was attached to an umbilical cord plugged into a receptacle in the top of the cage. The cord extended through a sealed port leading to the monitoring and recording station.

Recording was accomplished using the Portable Animal Recording Test System (PARTS) shown in Figure 5 and developed under Douglas IRAD programs (Reference 2).

#### GAS ANALYSIS

The atmosphere of the lavatory exhaust and cabin was monitored during each test using the equipment shown in Figure 6. The results were computer-recorded. The lavatory exhaust was examined for its content of  ${\rm CO_2}$ ,  ${\rm CO_2}$ , and such tota! hydrocarbons as  ${\rm CH_4}$  equivalents, while  ${\rm CO}$  and  ${\rm CO_2}$  were measured in the

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cabin at the subject's cage. The equipment used for determining the content of these gases included:

#### Lavatory Exhaust Analysis

Gas	Λnalyzer	Range	Sample Flow Rate
Carbon monoxide	MSA Model 303	0-10%	1 1pm
Carbon dioxide	Beckman Model 864	0-20%	l lpm
0xygen	MSA Model 802	0-25%	2 1pm
Total hydrocarbons	MSA Model 200	0-20%	2 1pm

#### Cabin Atmosphere Analysis

Gas	Analyzer	Range	Sample Flow Rate
Carbon monoxide	MSA Model 303	0-5000 ppm	1 1pm
Carbon dioxide	MSA Model 303	0-2.5%	l lpm

The sampling lines leading to the analysis equipment were 1/4-inch OD stainless-steel tubing. Before analysis, the sample was filtered with a Pall Epocel 3 cartridge, zinc dust, and calcium sulphate to remove particulates, acid gases, and water, respectively. Hydrocarbons were sampled using a heated line. Delay time between the event and its measurement was between 30 and 60 seconds.

The lavatory exhaust and the cabin air were sampled using two NASA JSC-furnished bubbler systems, as shown in Figure 7. The NASA bubbler system sampled air from the lavatory exhaust and in the vicinity of the rat cage in the cabin. The sampling lines were 1/4-inch OD teflon lines leading into impingers via a teflon manifold. The impingers contained 0.1-N NaOH. Each bubbler ran for 2 minutes, consecutively from the beginning of the test, for the first 12 minutes. The flow rate was 0.5 liters per minute. Additionally, a continuous sample was taken at each location for the duration of the test at a rate of 1 liter per minute.

Each bubbler sample was analyzed for HCL, HF, and HCN as follows:

- Chlorides (as HCL) Measured by potentiometric titration with AgNO<sub>3</sub> using a chloride ion selective electrode.
- Fluorides (as HF) Measured using a fluoride specific ion selective electrode.
- Cyanide (as HCN) Measured using the pyridizine-pyrazolone method.

FUEL AND IGNITION

The airline trash fuel consisted of four trash-filled bags as shown in Figure 8. The contents of each consisted of:

Paper towels (crumpled)	0.907 kg (2 1b)
Waxed paper cups	0.045 kg (0.1 1b)
Polystyrene cups	0.181 kg (0.4 lb)
Polyethylene trash bag	0.064 kg (0.14 lb)
Total per bag	1.197 kg (2.64 lb)

The trash was ignited using a resistance coil energized by computer command as shown in Figure 9.

The above-described fuel source was determined by a previously conducted program (Reference 5) under NASA Contract NAS9-14948.

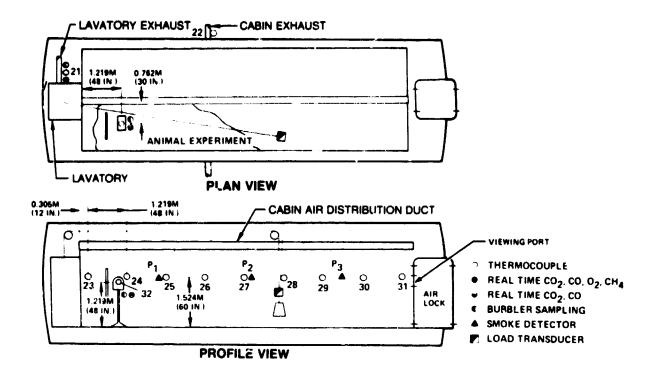


FIGURE 2. CABIN INSTRUMENTATION

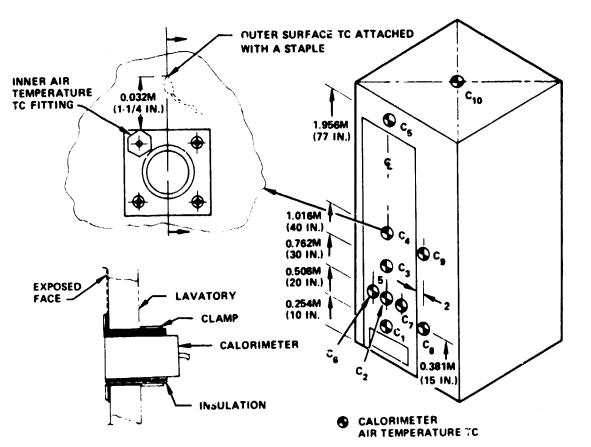


FIGURE 3. LAVATORY INSTRUMENTATION

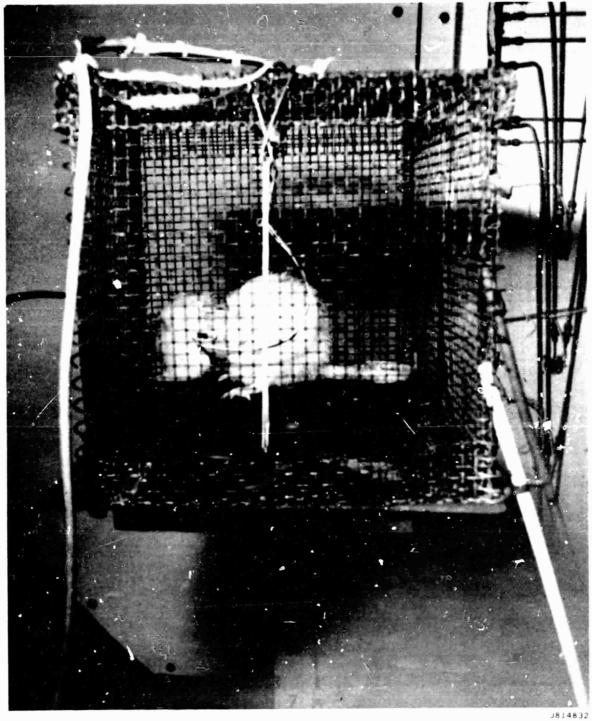
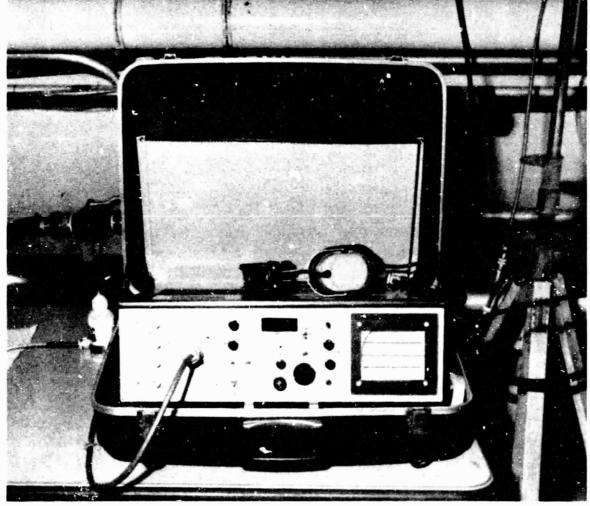


FIGURE 4. INSTRUMENTED ANIMAL SUBJECT

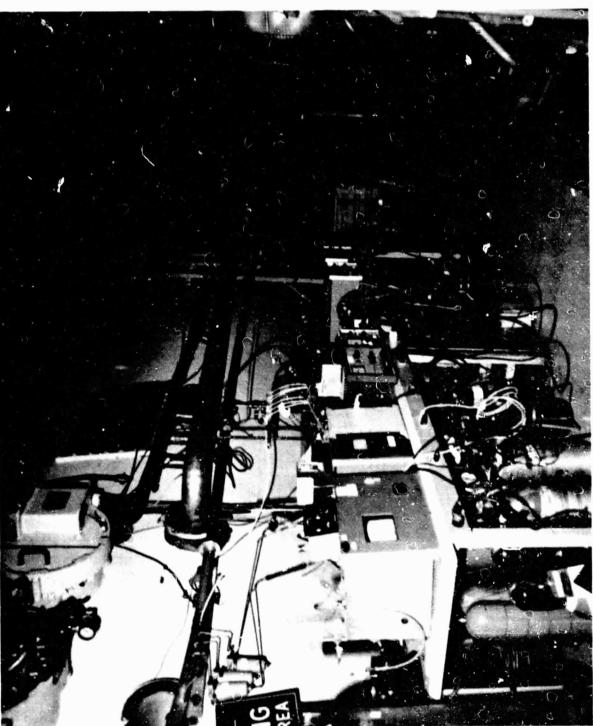


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FIGURE 5. PORTABLE ANIMAL RECORDING TEST SYSTEM (PARTS)



FIGURE 6. GAS ANALYSIS EQUIPMENT



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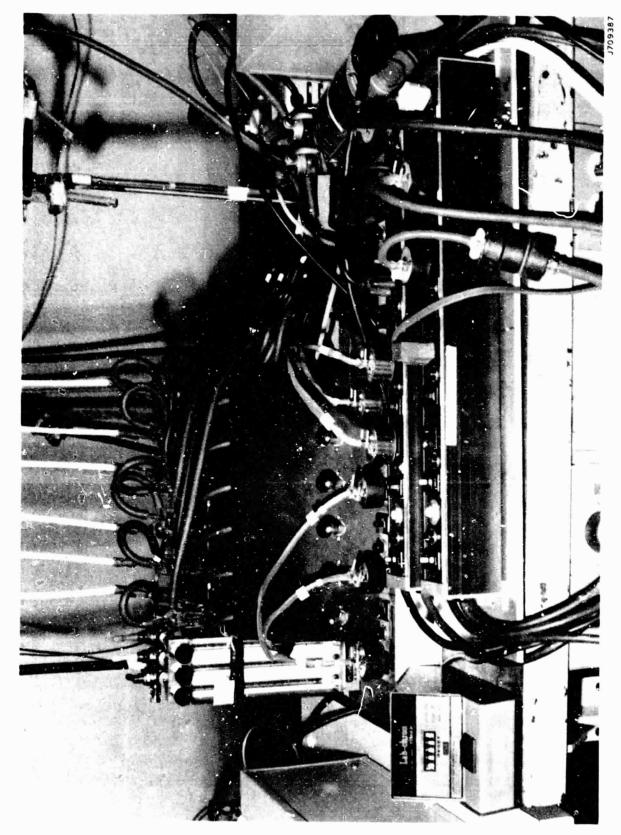


FIGURE 7. NASA-FURNISHED BUBBLER SYSTEM

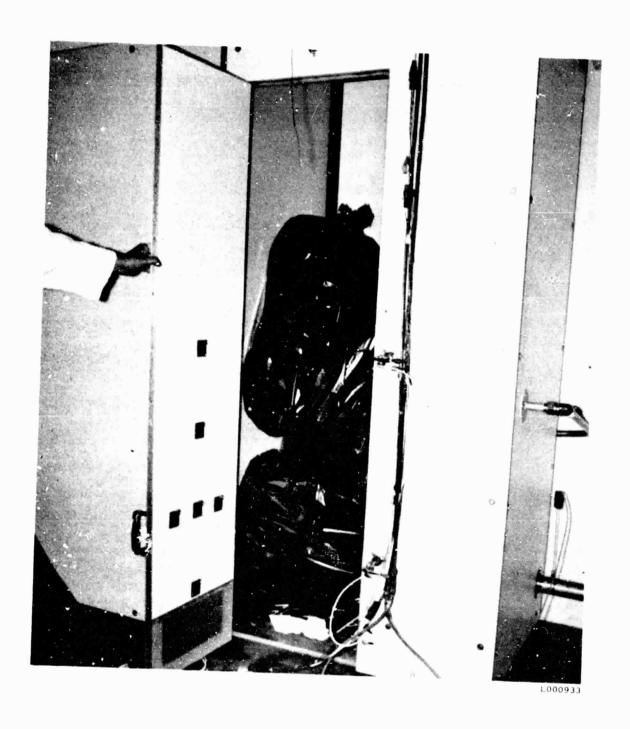


FIGURE 8. FOUR BAGS OF AIRLINE TRASH



FIGURE 9. FUEL IGNITOR

#### PANEL TEST RESULTS

The physical post-test evidence and data obtained during each test are reviewed in this section. Test data for test Modules A and B may be found in Appendices 1 and 2. The test results are discussed below. The figures referred to are contained in Appendix 1.

#### TEST MODULE A

The condition of the Module A test area before and after the test is shown in Figures 10 through 21.

Figure 13 shows the results of the hinge attachment failure caused by inadequate support for the hinge screws. The failure allowed the door to be displaced downward creating a top vent which caused a change in the ventilation pattern within the module. This in turn increased the intensity of the fire over the full height of the module. At 300 seconds, calorimeter 7 registered  $31 \text{ W/cm}^2$  (28 BTU/ft<sup>2</sup> sec), almost twice the maximums of either the baseline or Module B.

The block grid lines visible in Figure 14 are the result of core shrinkage causing loss of insulation and a local increase in heat transm ion. One face of the back panel was removed to show this shrinkage and resultant voids, Figure 15. The only effects on the adjacent aft bulkhead are the discolorations where hot gases from these core fissures impinged on the adjacent surface. Damage to the left side of the test module and the adjacent panel surface are visible in Figure 16. A view of the opposite side of the adjacent panel reveals the extent of the transmitted damage, Figure 17. Damage to the ceiling, back, and floor panels was limited to the melting of wire insulation on the ceiling and reticulation of the core with some surface discoloration.

The interior of the lavatory, Figure 18, illustrates the general condition of all panels. Resin burnout was extensive; it was complete in the case of the washstand side and a major portion of the inner door surface.

#### TEST MODULE B

The condition of the Module B test area is shown in Figures 22 through 31. The insulated panels were on the front, Figure 24, and right side, Figure 25, where exterior damage was limited to local areas of the decorative laminate. These areas indicate that the maximum fire intensity within the module was limited to the lower one-third of the lavatory. The interior of the lavatory is shown in Figures 26 and 27. During the test, the washstand-side panel warped inward, pulling away from the 1-inch 1699-1pm (6 CFM) line which deflected down into the plenum. This would have had the effect of reducing activity in the upper area of the lavatory. The exterior effect on the left side panel and the transmitted damage to both sides of the near wall of the adjacent module are shown in Figure 28 and Figure 29. The floor was extensively damaged (Figure 30) while only the decorative laminate was damaged on the ceiling panel. Figure 31 illustrates damage to the bulkhead adjacent to the right wall.

#### GAS CONCENTRATIONS

The concentrations of hydrogen chloride, hydrogen cyanide, and hydrogen flouride gases are provided in Table 1 (References 3 and 4). The acid gas concentrations represent an average concentration over the 2-minute sampling interval. The values listed for the continuous bubbles represent an average concentration over the entire 1 hour of the test.

Module B generated the largest amount of HF in the lavatory followed by Module A. Module B generated the largest amount of HCL in the lavatory followed by the baseline (Reference 5). Module A generated the largest amount of HCN followed by Module B.

The higher level of HF and HCL in Module B possibly was due to the differences in decorative used. The higher level of HCN in Module A was probably due to the polyimide foam used in the panel construction.

TABLE 1
GAS CONCENTRATION RESULTS FROM NASA BUBBLERS

	TIME	HF (I	PPM)	HCI	PPM)	HCN (I	PPM)
LOCATION	(SEC)	MOD A	MOD B	MOD A	MOD B	MOD A	MOD B
LAVATORY EXHAUST	0-120	50.1	34,935	+.7.1	6023.5	10.34	4.94
LAVATORY EXHAUST	121-240	20.6	118.2	<7.1	252.4	59.24	223.6
LAVATORY EXHAUST	241-360	117.1	100.5	< 7.1	81.7	103.4	40.2
LAVATORY EXHAUST	361-480	29.5	588.7	< 7.1	320,7	89.61	112.9
LAVATORY EXHAUST	481-600	93.7	684.0	< 7.1	368.8	291.50	211.6
LAVATORY EXHAUST	601-720	220.0	1604.6	98.6	867.0	677.1	444.4
LAVATORY EXHAUST	0-3600	20.6	160.5	17.07	25.7	46.04	19.68
CABIN	0-120	<7.7	9.0	<71	26.9	<4.7	3,53
CABIN	121-240	<7.7	5.0	~7.1	13.4	<4.7	3.10
CABIN	241-360	9.6	5.6	<7.1	40.4	<4.7	1.83
CABIN	361-480	12.1	5,4	<7.1	40.4	<4.7	1.60
CABIN	481-600	15.1	6.1	<7.1	13.4	6.58	0.91
CABIN	601-720	16.9	6.2	< 7.1	<7.1	7.9	0.77
CABIN	0 3600	4.18	2.1	5.84	7.96	1.5	3.26

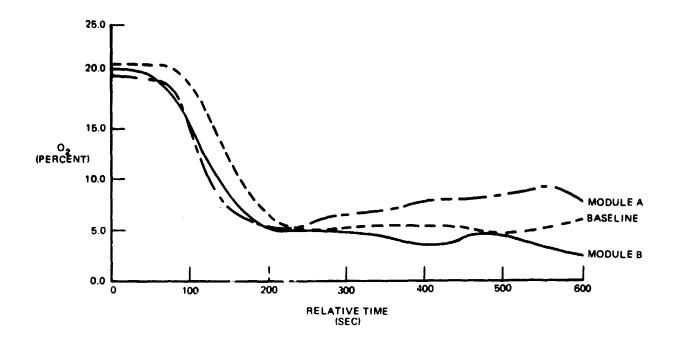
The oxygen, carbon monoxide, carbon dioxide, and hydrocarbon test data from Appendix 2 are summarized in Plots 1 through 4 for direct comparison of results. As can be clearly seen on these plots, the  $\mathbf{0}_2$ ,  $\mathbf{0}_2$ , and  $\mathbf{0}_3$  and  $\mathbf{0}_4$  for Modules A and B follow basically identical lines. Only in the  $\mathbf{0}_2$  plot is there a noticeable differentiation in data. From these plots it can be assumed that, for these three tests, Module A and B materials produce less  $\mathbf{0}_2$  and  $\mathbf{0}_4$  than the baseline. This difference is negligible and cannot be used to differentiate between Modules A and B.

#### SMOKE DENSITY

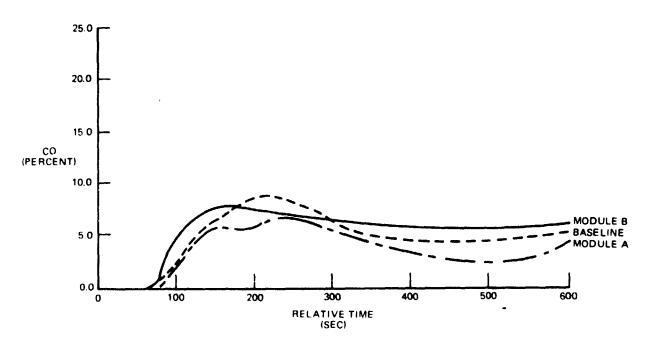
Smoke density for this series of tests is presented in Plot 5. These data were retrieved from Appendix 2.

Module A's low transmission value is due to the failure of door hinges. This failure dropped the door and allowed additional smoke to escape.

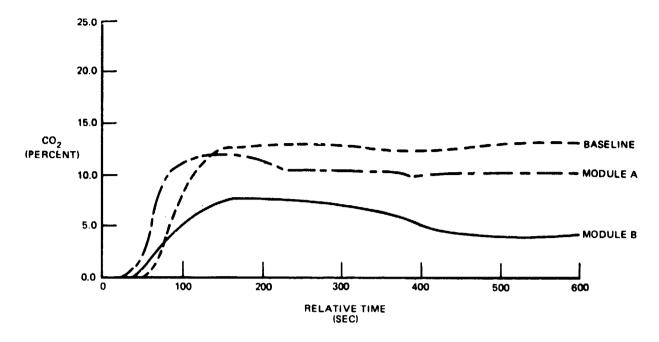
The maximum reduction in visibility in each case occurred at the photometer farthest from the test module. This is consistent with the results of the open-door tests of Reference 5, in which the smoke could be viewed traveling



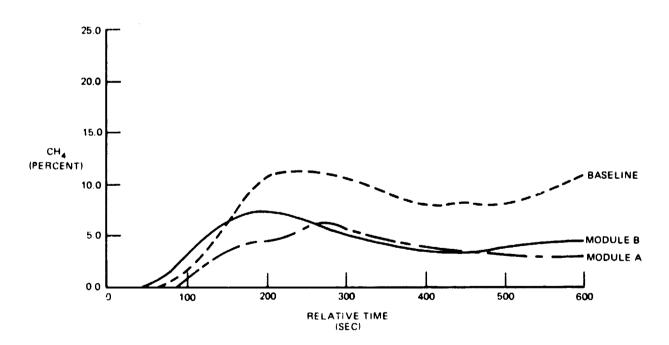
PLOT 1. LAVATORY 02



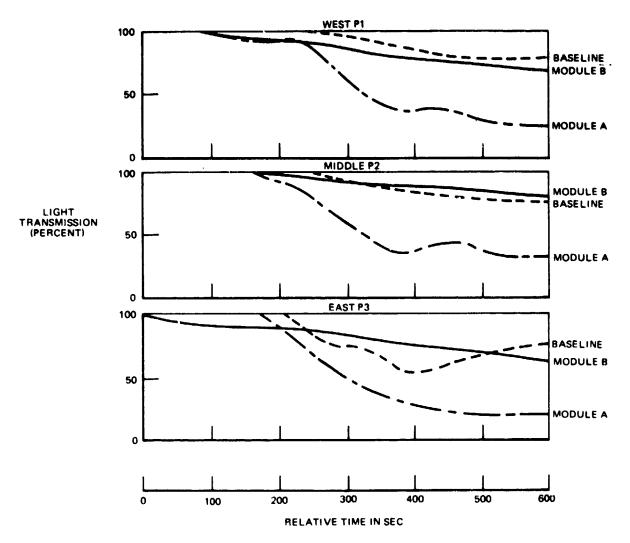
PLOT 2. LAVATORY CO



PLOT 3. LAVATORY CO2



PLOT 4. LAVATORY CH4



PLOT 5. LIGHT TRANSMISSION

along the ceiling and, upon reaching the end of the chamber, being deflected down resulting in the smoke meter at the far end of the chamber being affected first.

These data show that, if these fires took place aboard an aircraft, passenger visibility would be impaired at approximately 200 seconds after the start of the fire no matter which materials were used in construction of the lavatory.

#### THERMAL RESULTS

The temperature at the lavatory exhaust is probably the best measure of the average fire intensity. Examination of exhaust data indicates that the temperature at the exhaust was approximately the same for both the baseline and B modules up to 1200 seconds reaching a maximum of  $875^{\circ}$ C, while that of Module A was lower up to  $500^{\circ}$ C seconds, rapidly increased until 880 seconds to a value of  $950^{\circ}$ C, then dropped back to the level of the other two tests.

The heat flux during the initial 10 minutes was highest in Module A except at Calorimeters 7 and 8. These recorded the highest flux in the baseline.

Module B had low heat flux levels with the exception of Calorimeter 1.

Temperatures within the cabin were moderate in all tests with the following maximums recorded:

	Animal Cage	Calorimeter	TC-24
Baseline	46.11°C (115°F)	C7-31 w/cm <sup>2</sup> (28 BTU/ft <sup>2</sup> sec)	48.89 <sup>0</sup> C (120 <sup>0</sup> F)
Module A	50.56°C (123°F)	C7-17 w/cm <sup>2</sup> (15 BTU/ft <sup>2</sup> sec)	60.56°C (141°F)
Module B	44.11°C (106°F)	C1-15 w/cm <sup>2</sup> (13.5 BTU/ft <sup>2</sup> sec)	42.78 <sup>0</sup> C (109 <sup>0</sup> F)

#### TEST MODULE WEIGHT LOSSES

The weight loss information for Modules A and B and the baseline module (Reference 5) are listed in Tables 2 and 3. Table 2 shows the gross results and Table 3 the loss in weight and percent loss for individual panels. The data in Tables 2 and 3 were obtained by weighing each panel during module assembly. After each test, the ash and residuals inside the lavatory were removed and weighed. Each panel was then removed and weighed taking care whenever possible to combine droppings caused by the panel removal with the panel itself for the weighing. After removing all panels, the floor was swept and the weight of the sweepings was combined with that of the previously weighed ash and residual matter within the lavatory. The baseline lavatory lost 29 percent of its original weight, Module A lost 28 percent, and Module B lost 26 percent. For these tests, each percentage point is equivalent to approximately 500 grams.

#### BIOLOGICAL RESULTS

The results of the data analysis verified the real-time impression at the time of the test that there were no significant cardiac arrhythmias in any of the rat subjects throughout the tests. There were some minor respiratory pattern changes, most likely due to the irritating qualities of the dense smoke. The respiratory amplitude was reduced in some of the rats while it increased in others. Examination of the readout of the gas concentrations developed during the test showed that HF, HCl, and HCN concentrations were all too low to produce arrhythmias.

TABLE 2
MODULE AND SOURCE FUEL WEIGHT LOSS

	8.4	SELINE	MOD	ULE A	MODULE 8		
ITEM	ke	(LB)	ke	(LB)	kg	(LB)	
PANELS AND FUEL	52.38	(115.48)	43.35	(95.58)	40.46	(89.20)	
PANELS (POST-TEST)	36.37	(80.19)	30.65	(67.57)	28.90	(63.72)	
ASH AND RESIDUALS	0.83	(1.82)	0.82	(1.81)	1.30	(2.87)	
WEIGHT LOSS	15.18	(33.47)	11.88	(26.20)	10.26	(22.61)	
PERCENT LOSS		28.98	27	7.41	25	.35	

TABLE 3
INDIVIDUAL PANEL WEIGHT LOSS

	BASEL	INE	MODUL	EA	MODULE B		
PANEL	WT LOSS kg (LB)	% LOSS	WT LOSS kg (LB)	% LOSS	WT LOSS kg (LB)	K LOSS	
TOP	0.53 (1.16)	17.3	0.41 (0.91)	16.2	0.14 (0.30)	6.9	
BACK	1.46 (3.22)	18.4	1.15 (2.54)	17.6	0.98 (2.16)	17.7	
NORTH SIDE	2.08 (4.59)	29.1	0 62 (1.36)	11.3	1.05 (2.32)	16.7	
SOUTH SIDE	1.24 (2.73)	19.4	1.34 (2.96)	24.0	1.28 (2.82)	28.2	
CABINET SIDE	1.43 (3.15)	40.4	2 39 (5 28)	4. 7	0.95 (2.09)	47.3	
CABINET TOP	0.30 (0.67)	32.2*	0 26 (0.57)	30 2	0.29 (0.65)	53.7	
FRONT WALL	2.34 (5.15)	19.2	1.37 (3.01)	14.7	1 63 (3.59)	14.9	
FLOOR	1 84 (4.06)	40.7	0.37 (0.82)	14.8	0.45 (0.99)	23.8	
TOTAL	11.22 (24.73)	24 6	7.92 (17.45)	20.5	6.77 (14.92)	20.1	

NOTE FOR THE PERCENT LOSS OF THE PANELS MARKED \* IN THE BASELINE A.4D MODULE B COLUMNS, THE INITIAL WEIGHT OF THE STEEL COVER PLATE WAS REMOVED

## **NEW TECHNOLOGY**

No inventions or new technologies were developed during this program.

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#### CONCLUSIONS

Smoke density, gas analysis, heat flux, temperature, respiration, and cabin temperature variation data show no major fire-resistance improvements by the advance materials when compared to the baseline. Two conclusions can be drawn. First, either the improved materials are no better than the contemporary materials in fire resistance or the contemporary materials are considerably better then indicated by earlier testing (Reference 5).

Second, since only one test of each material system was performed, it is possible that experimental differences could differ for a repeated test series. In either case, this test series may provide a basis for future and more comprehensive testing of aircraft lavatories.

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#### RECOMMENDATIONS

When using a polyimide foam in a panel, it would be advisable to use a compatible panel edge blocking for attachment of other components such as door hinges.

Secondly, it may be beneficial to again test the Module B configuration employing only insulated panels.

Thirdly, it may be beneficial to the airlines to develop a less hazardous means of trash storage.

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#### REFERENCES

- J. G. Gaume, "Animal Exposure During Burn Tests, Final Contract Report," Nasa Report CR 137802, January 1976
- 2. J. G. Gaume, "Bioassy Technologies," Douglas Report MDC J-7453, January 1977
- 3. P. Talley, "Engineering Report, NASA Lavatory Burn Test of 13 November 1978," Douglas Report MDC J-1780, November 1978
- 4. P. Talley, "Engineering Report, Gas Analysis for NASA Lavatory Burn Test of 24 January, 1980," Douglas Report MDC J-1824, January 1980.
- 5. D. M. Klinck, "Characterization of Secondary Ignition Sources in Unattended Compartments and Full-Scale Baseline Test," NASA Report NAS9-14948, December 1977

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# APPENDIX 1 BURN TEST PHOTOS

## MODULE A PHOTOS

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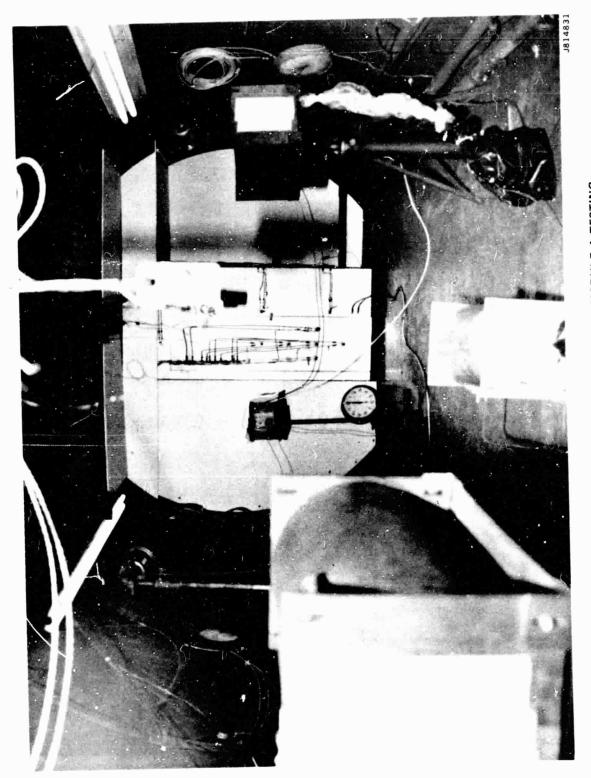
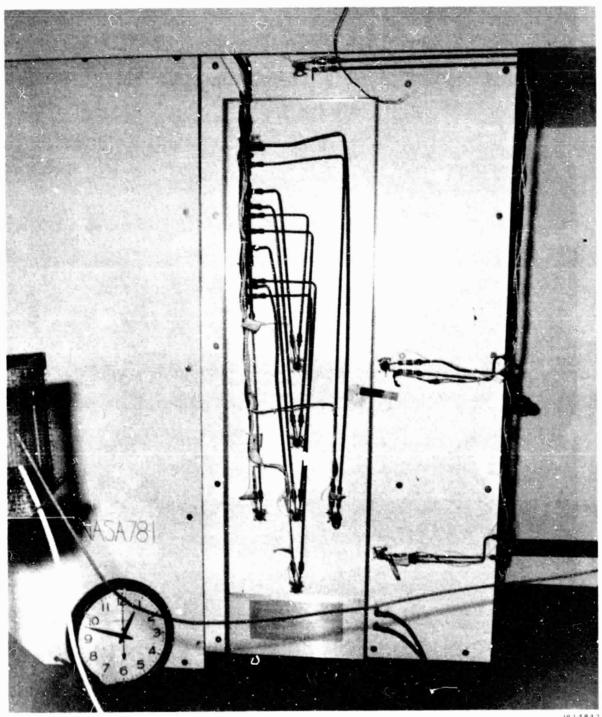


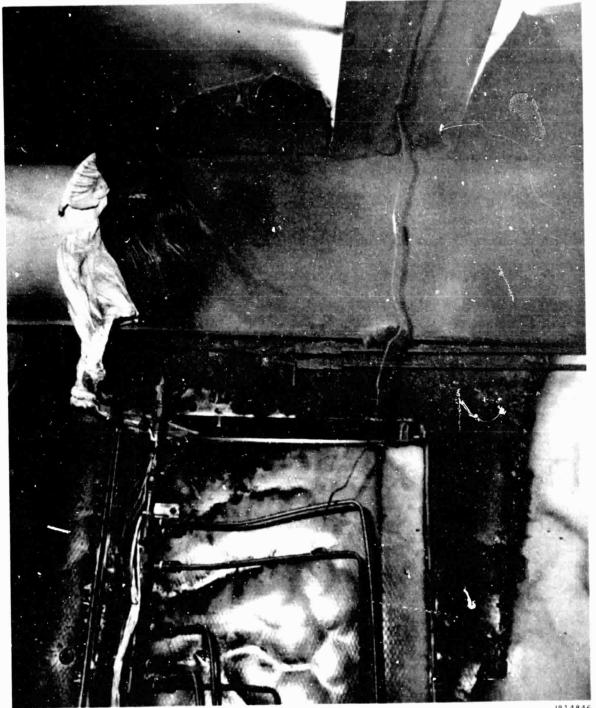
FIGURE 10. INTERIOR OF CFS AS CONFIGURED FOR MODULE A TESTING



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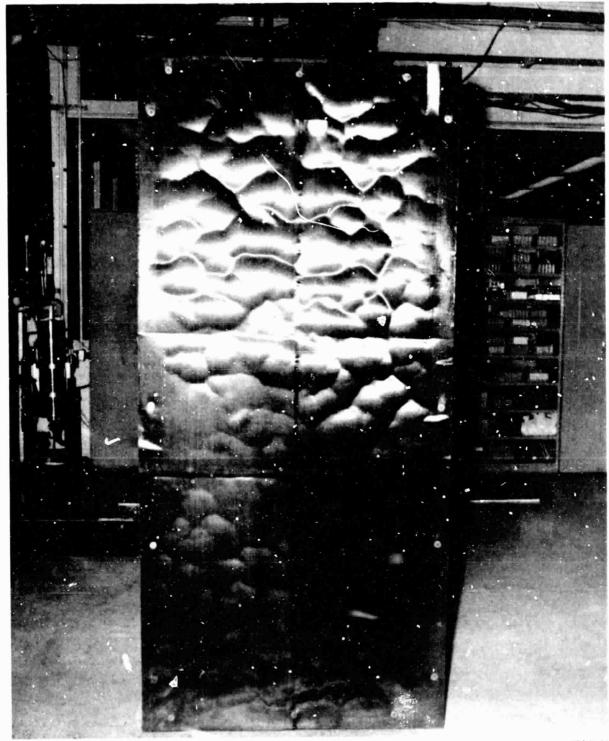
FIGURE 11. MODULE A INSTRUMENTATION

FIGURE 12. POST-TEST MODULE A EXTERIOR



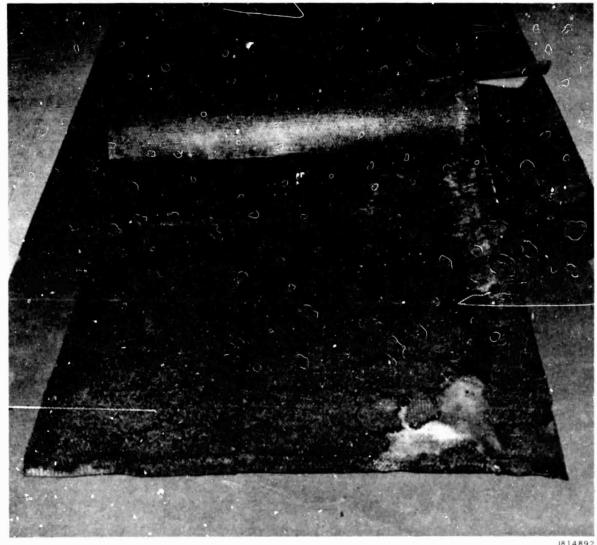
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FIGURE 13. DOOR DISPLACEMENT DUE TO HINGE ATTACHMENT FAILURE



J814L74

FIGURE 14. CORE SHRINKAGE CAUSING BLOCK GRID LINES ON EXTERIOR OF MODULE A BACK WALL



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FIGURE 15. INTERIOR OF MODULE A BACK WALL WITH FACING REMOVED

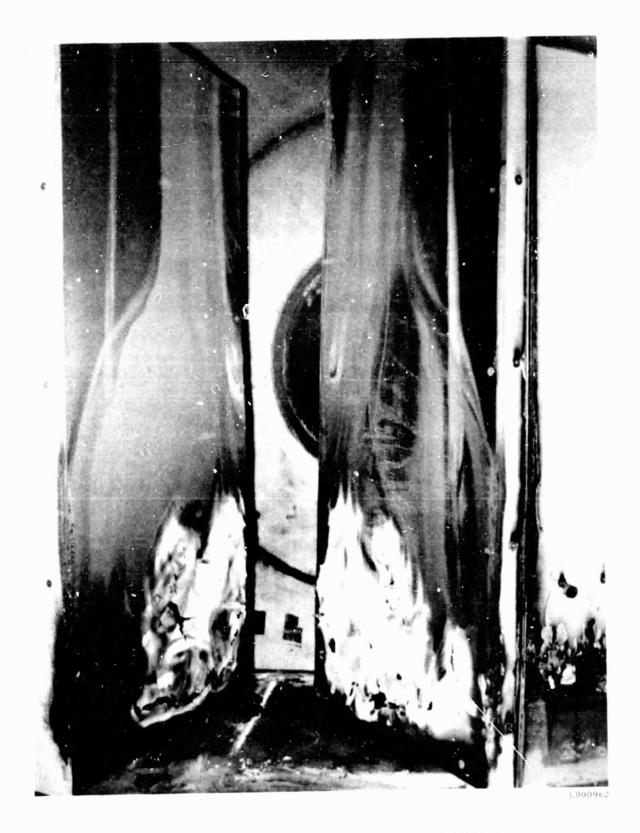


FIGURE 16. LEFT WALL OF MODULE A AND ADJACENT PANEL





FIGURE 18. MODULE A INTERIOR POST-TEST

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の(cm) (g): (g): (cm) (g)



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FIGURE 19. MODULE A INTERIOR WITH REMAINING FUEL

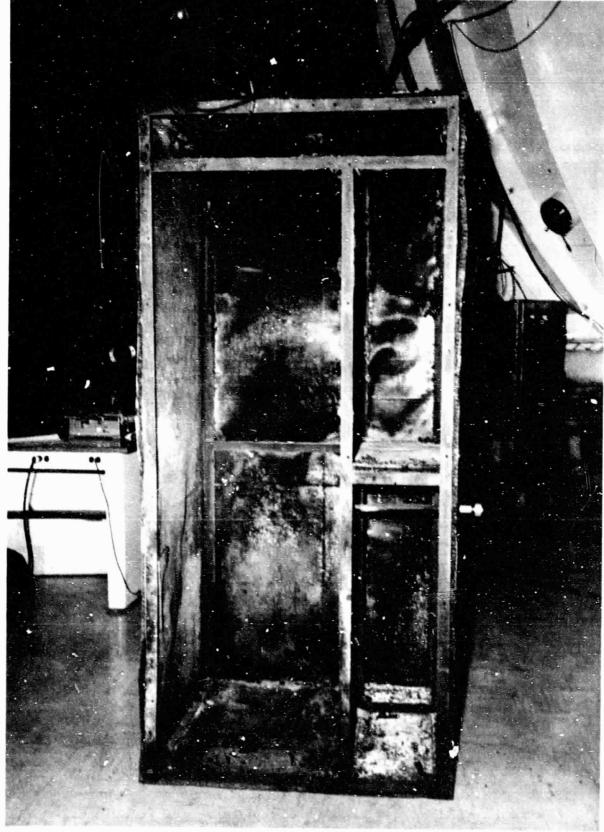
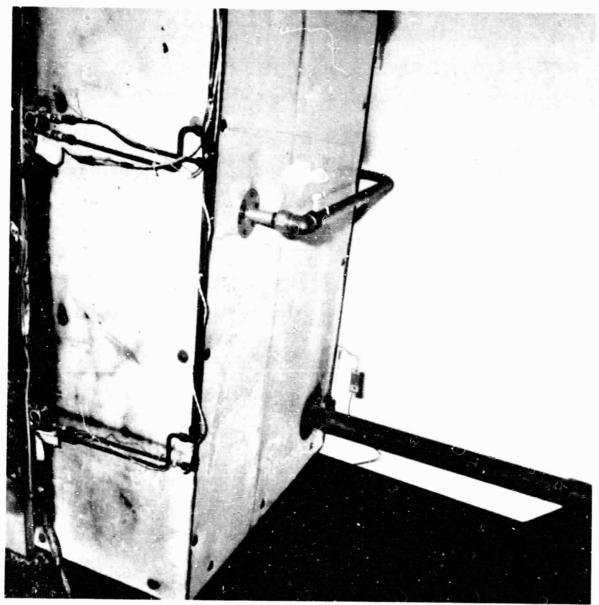


FIGURE 20 MODULE A INTERIOR WITH FRONT WAL! AND DOOR REMOVED

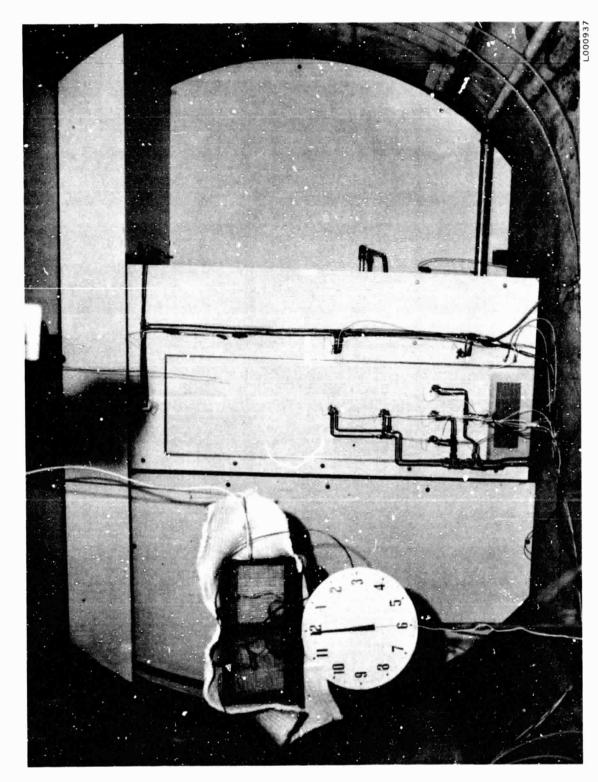
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FIGURE 21. RIGHT WALL OF MODULE A

## MODULE B PHOTOS



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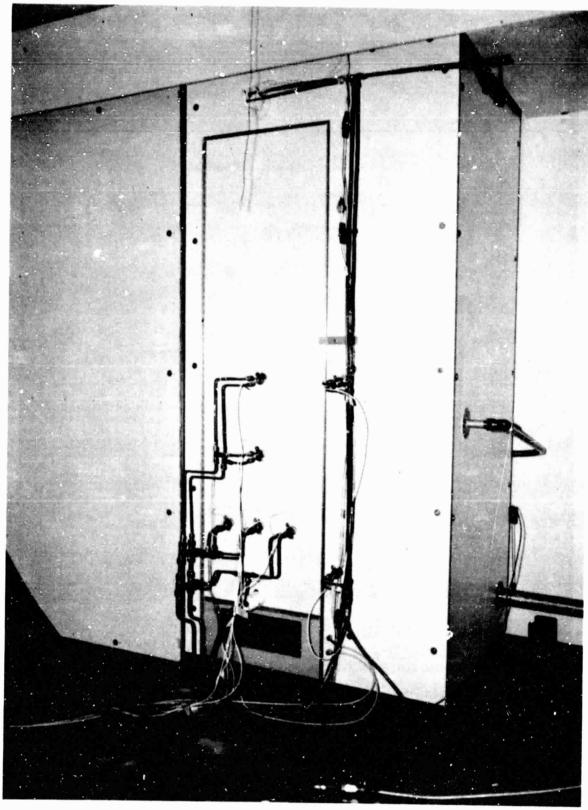
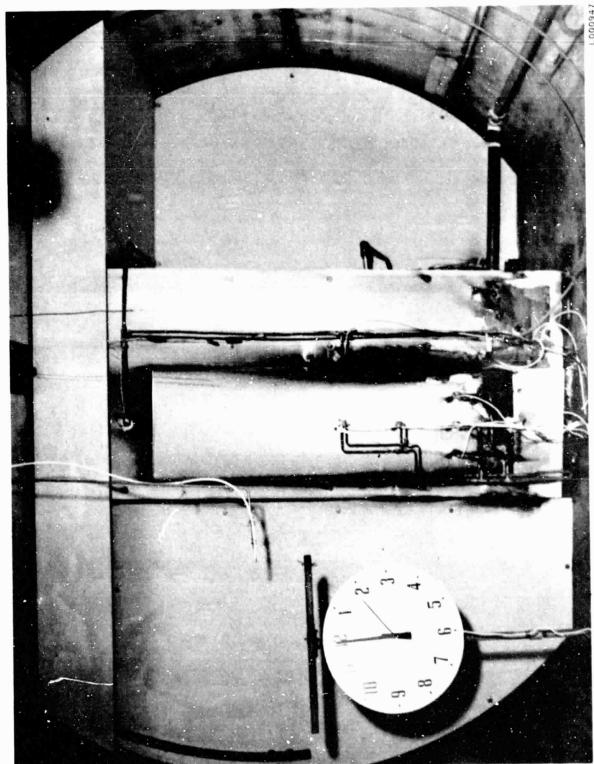


FIGURE 23. MODULE B INSTRUMENTATION

L000935



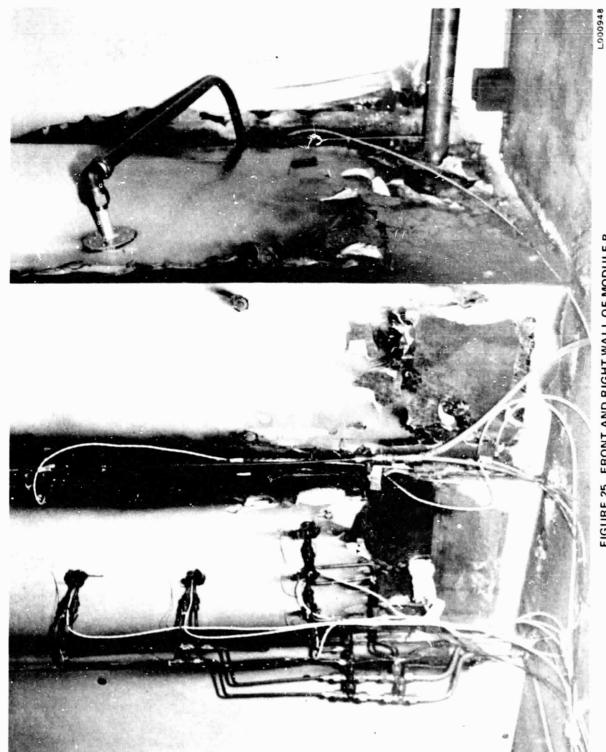
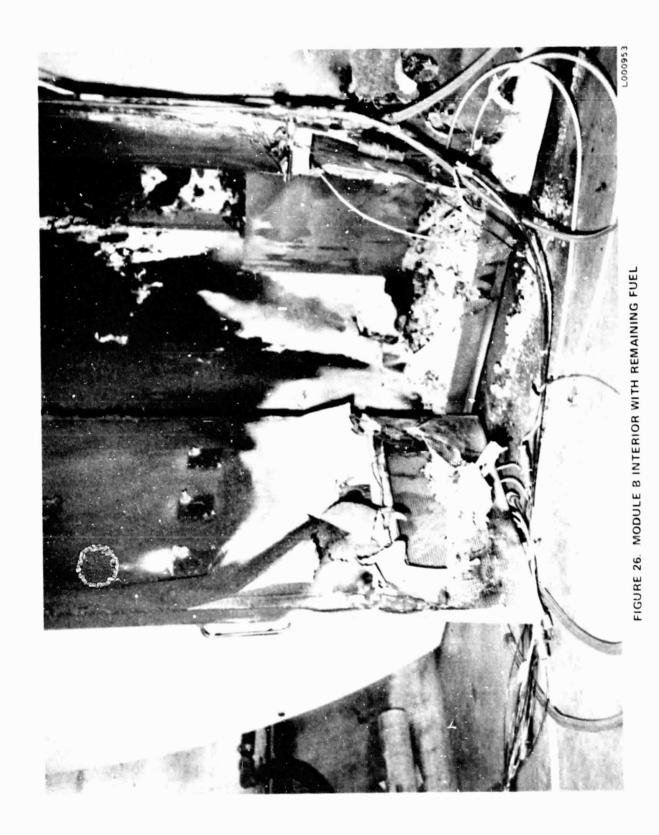


FIGURE 25. FRONT AND RIGHT WALL OF MODULE B



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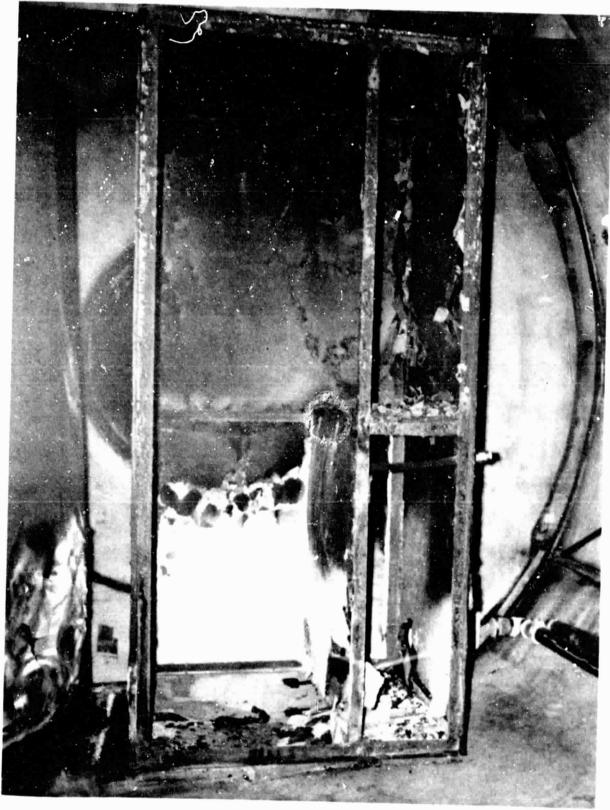


FIGURE 27. MODULE B INTERIOR WITH DOOR AND FRONT WALL REMOVED

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FIGURE 28. EXTERIOR VIEW OF MODULE B BACK WALL AND ADJACENT PANEL

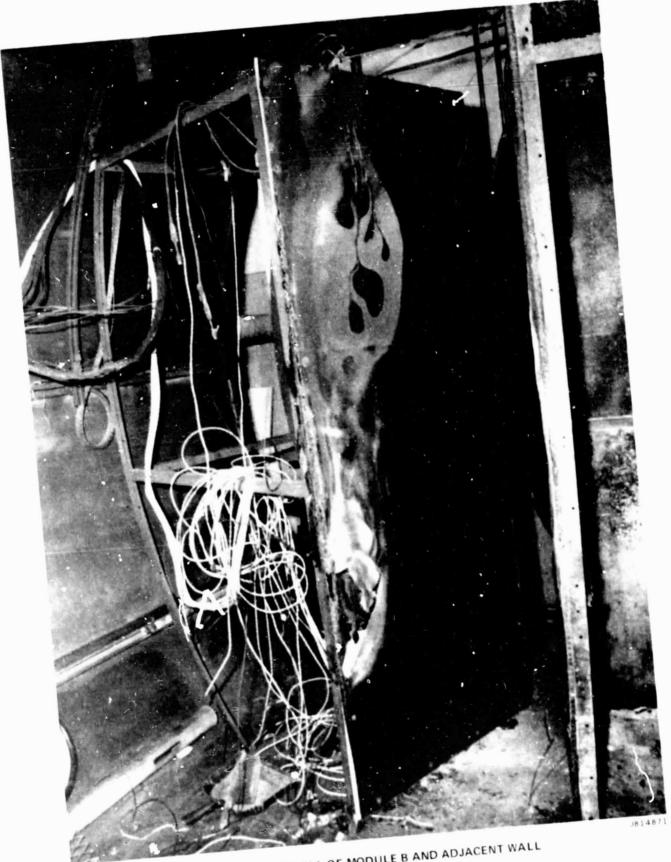
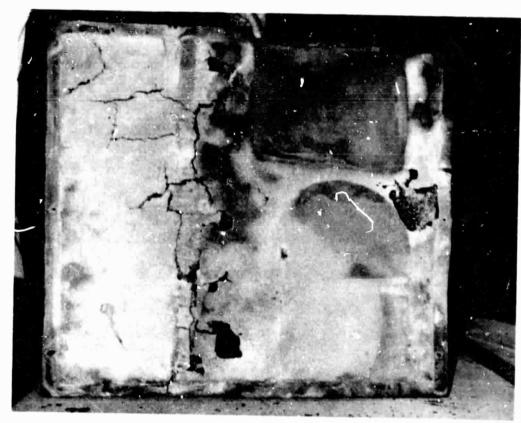


FIGURE 29. LEFT WALL OF MODULE B AND ADJACENT WALL





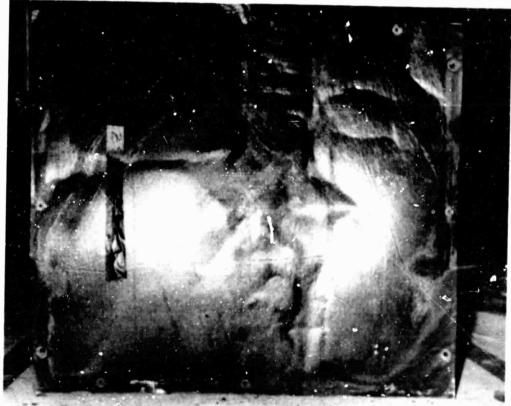


FIGURE 30. TOP AND BOTTOM OF MODULE B FLOOR

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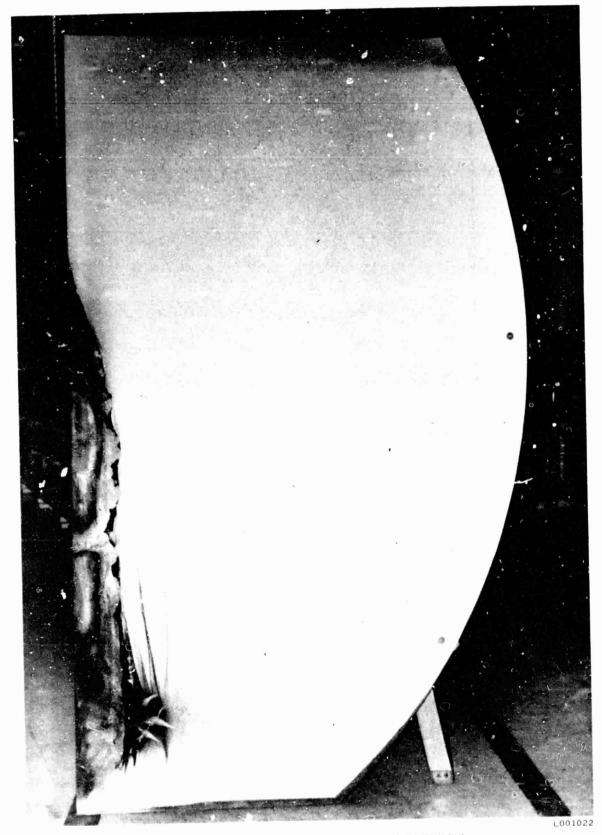
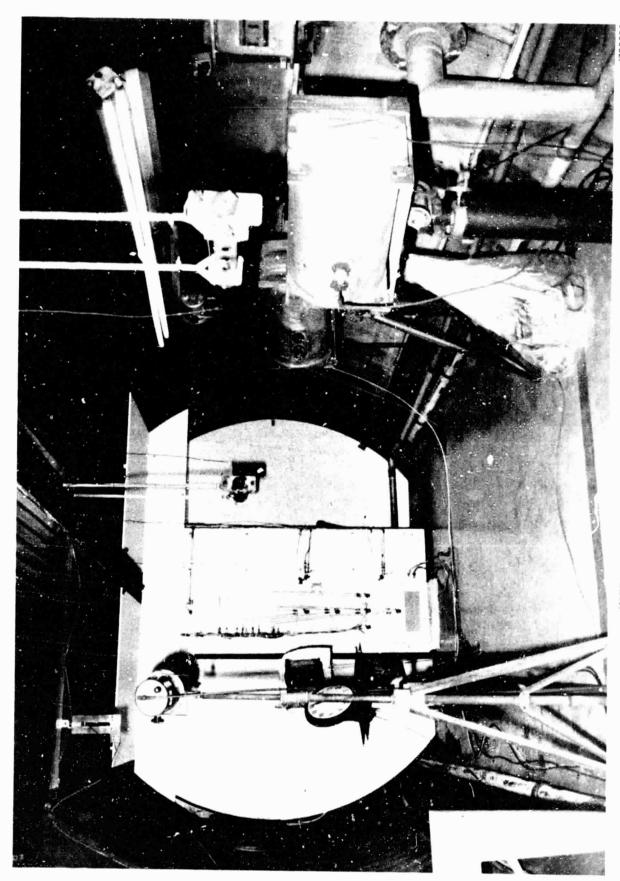


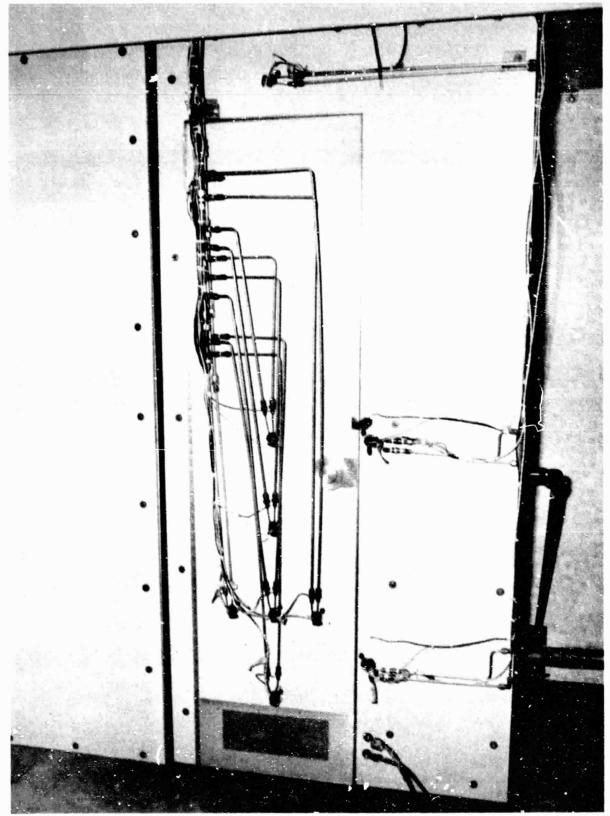
FIGURE 31. BULKHEAD ADJACENT TO RIGHT WALL

## BASELINE PHOTOS



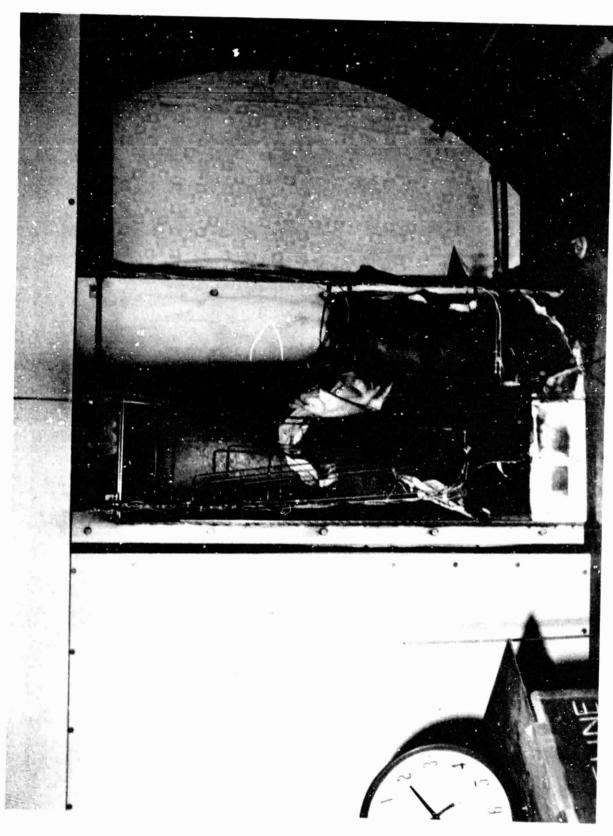


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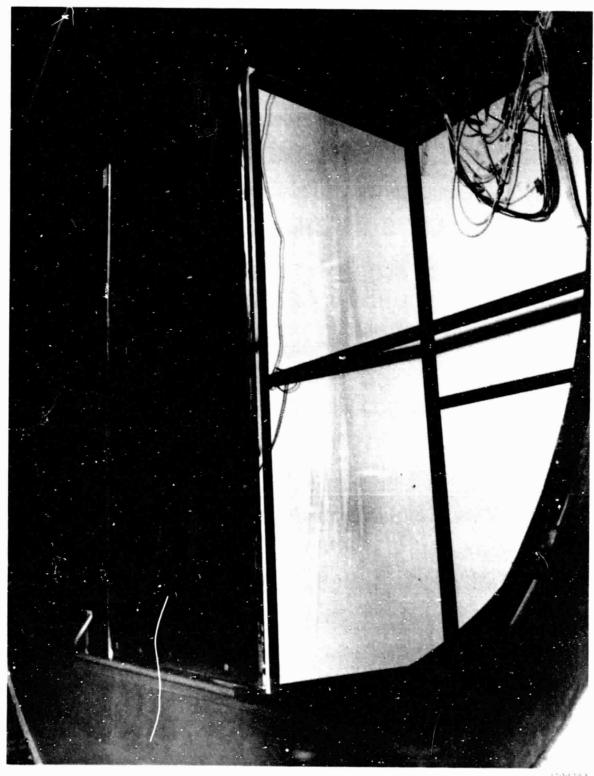
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BASELINE I STRUMENTATION





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EXTERIOR VIEW OF BASELINE BACK WALL AND ADJACENT PANEL

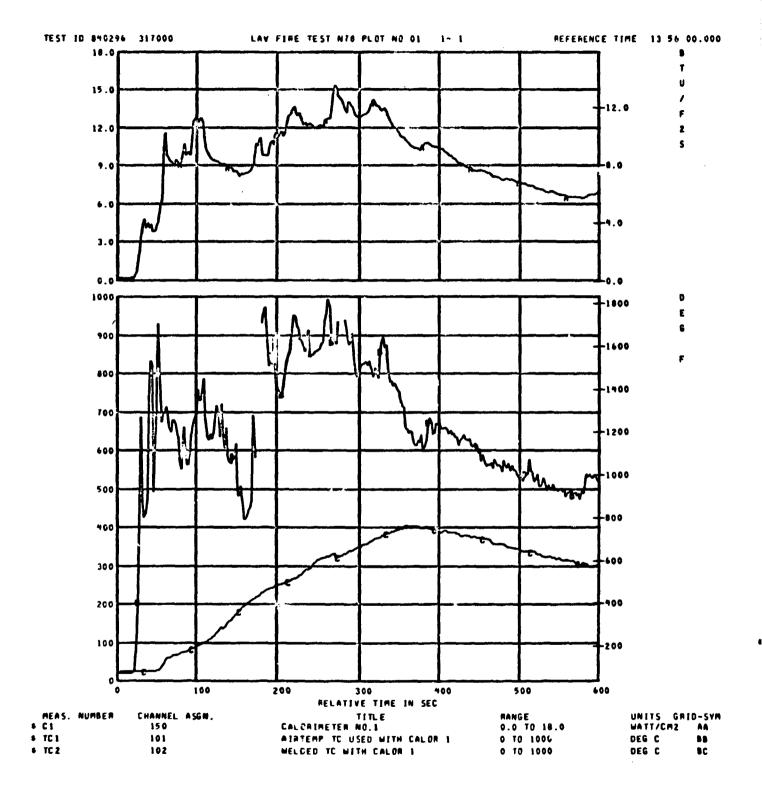


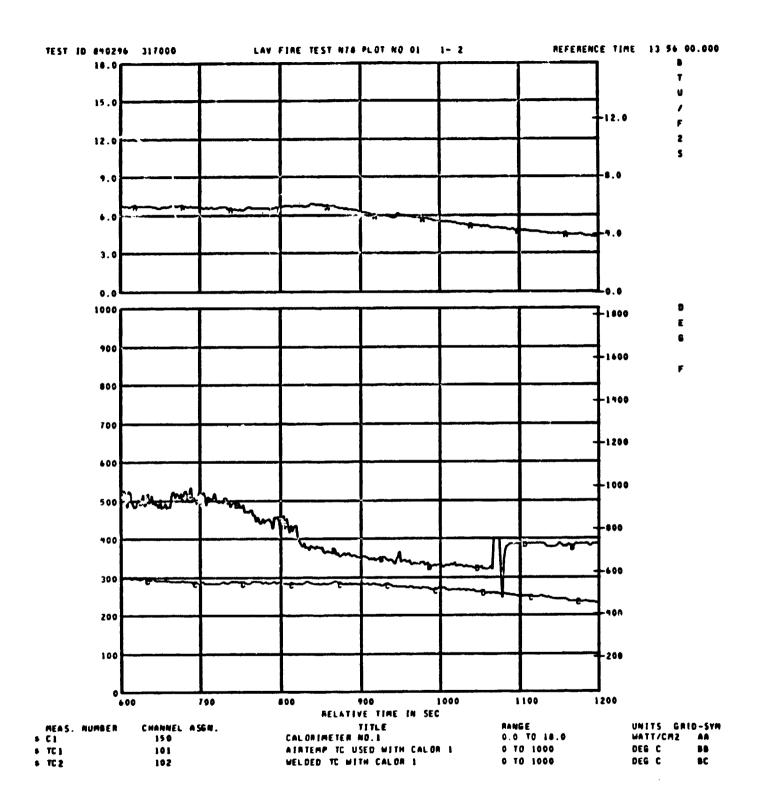
BASELINE INTERIOR WITH DOOR AND FRONT WALL REMOVED

## APPENDIX 2 BURN TEST DATA

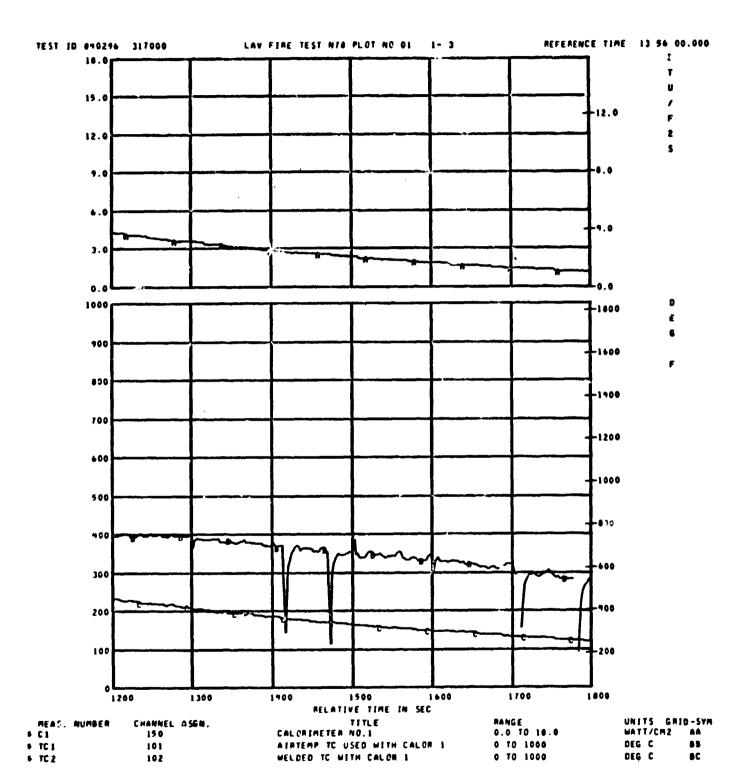
## MODULE A TEST DATA

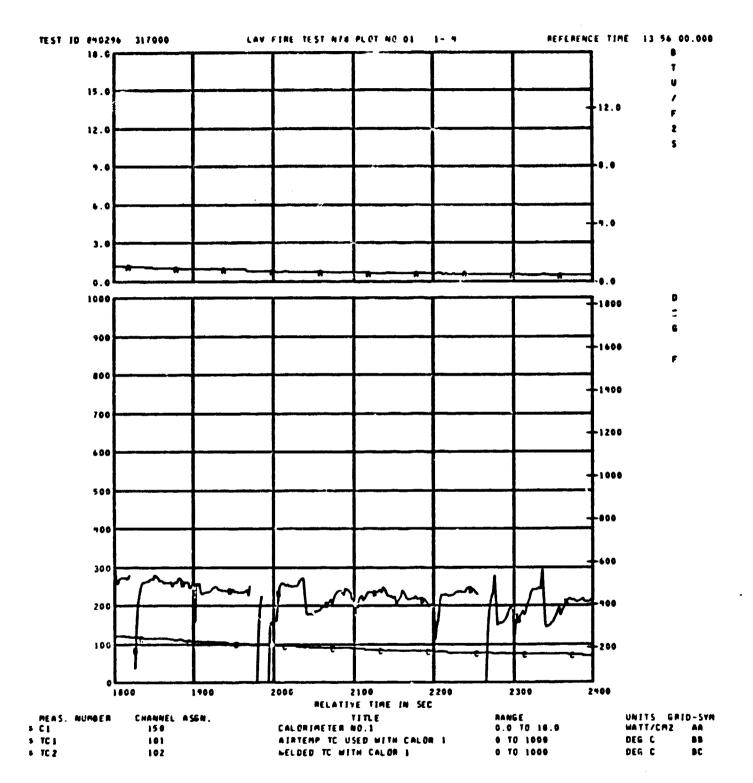
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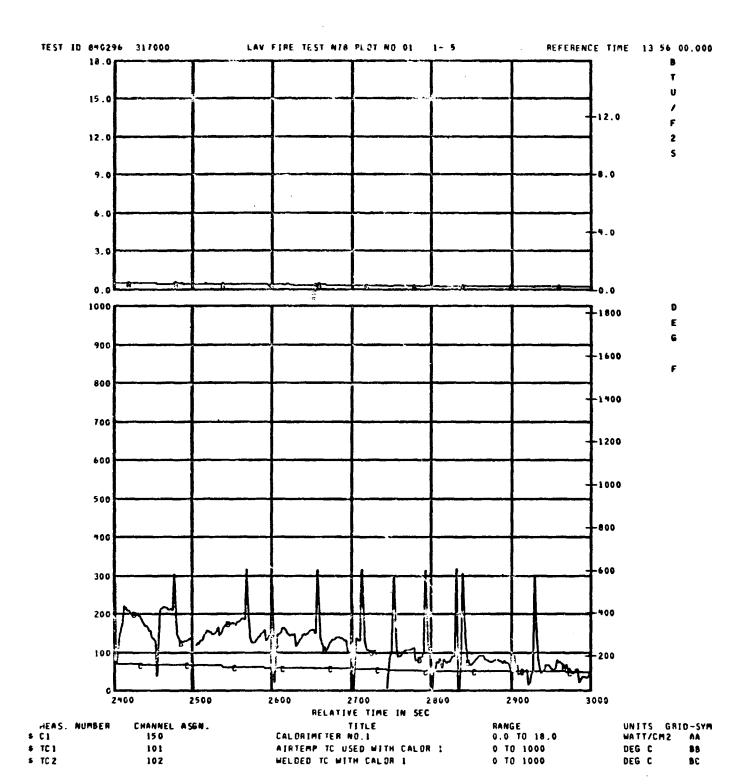


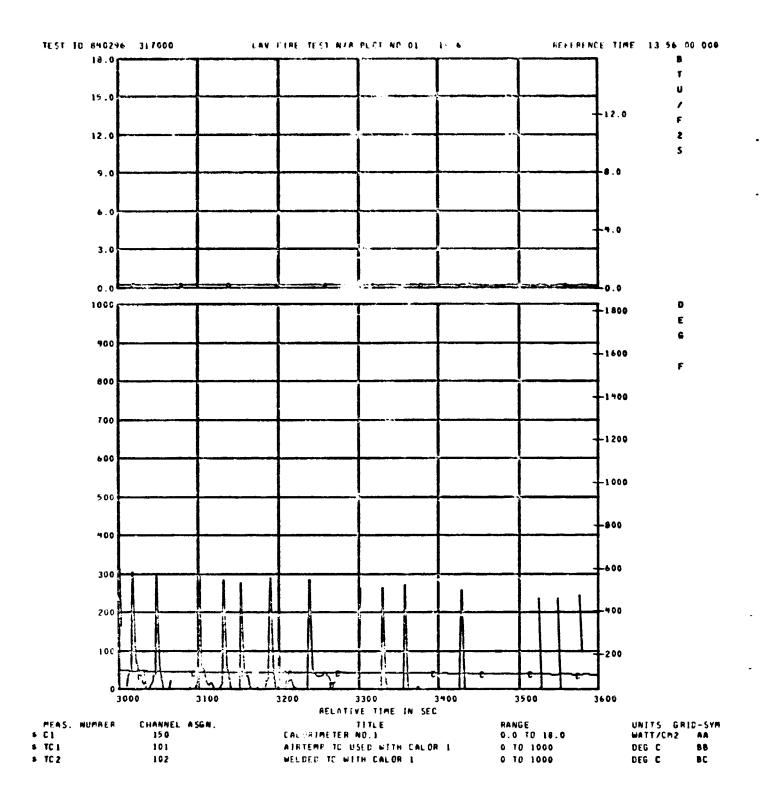


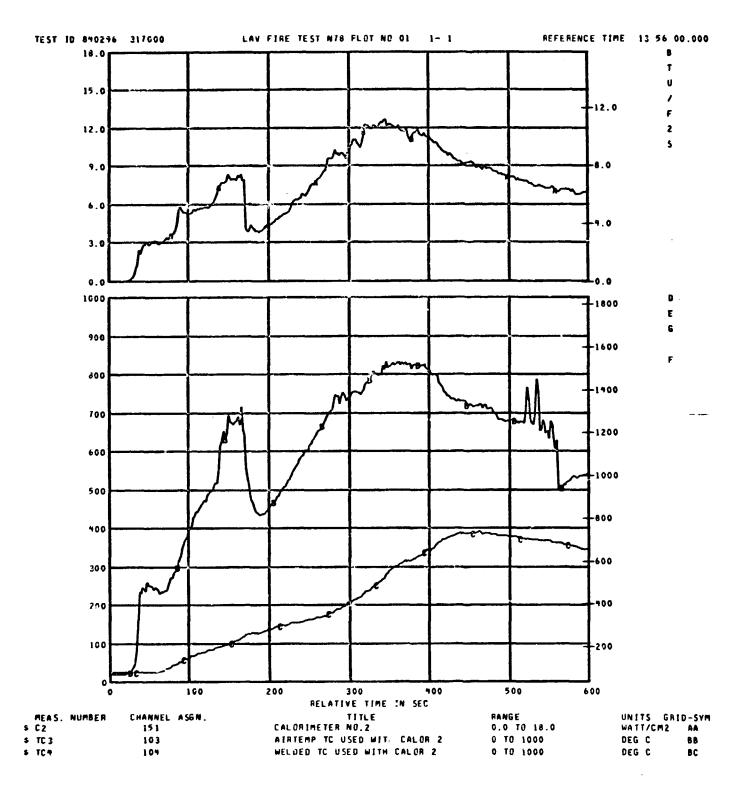
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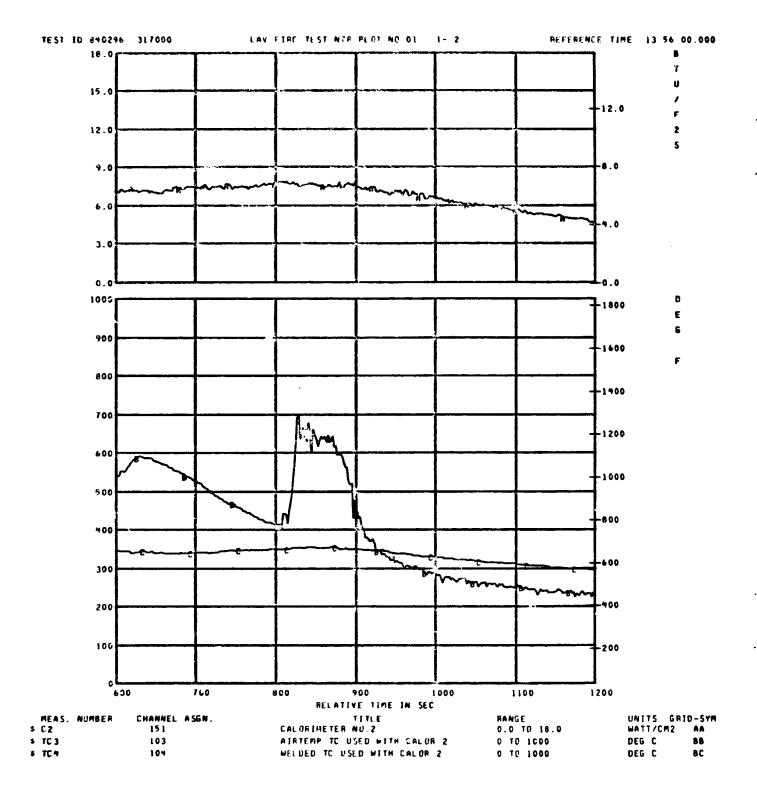


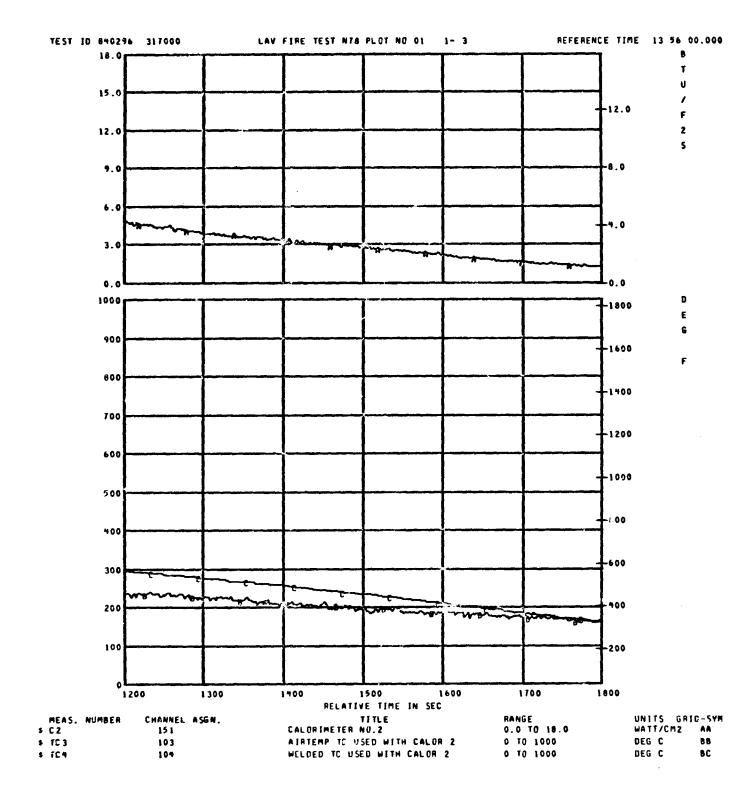


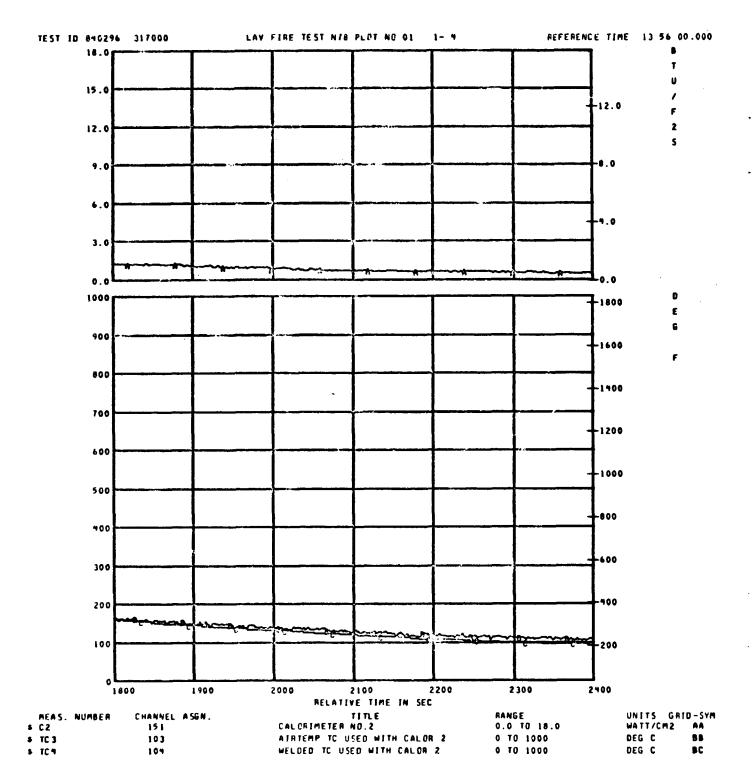


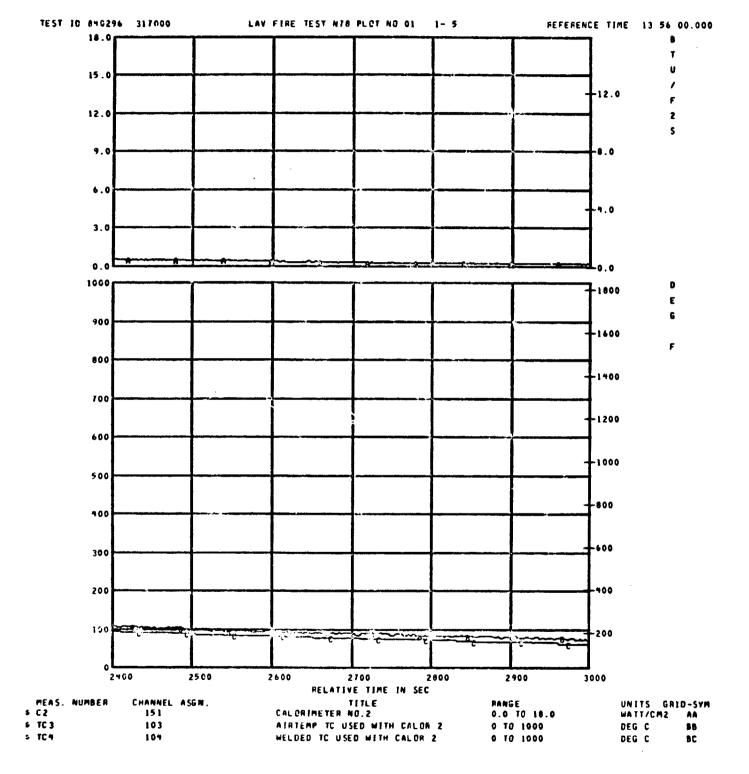


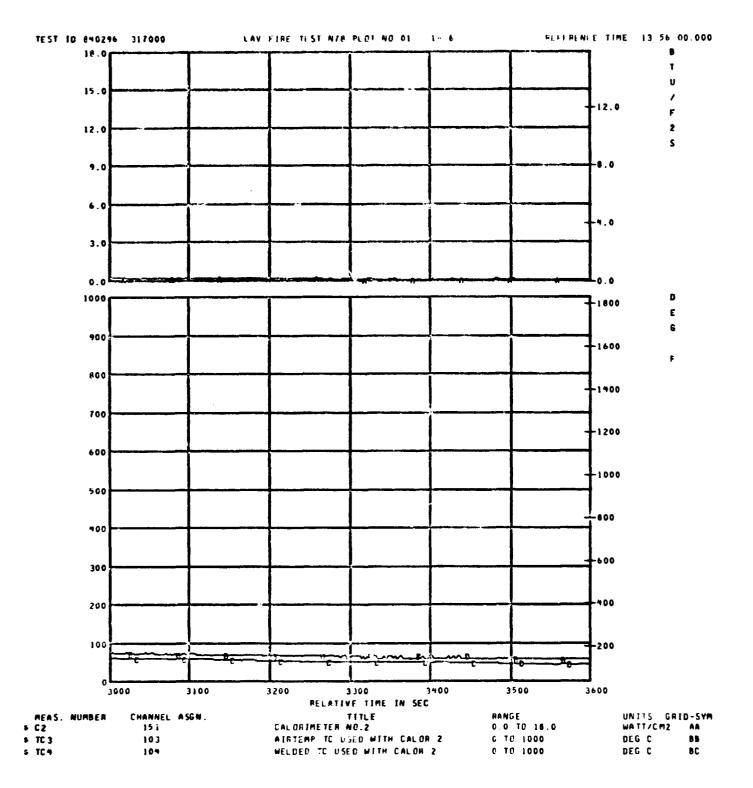




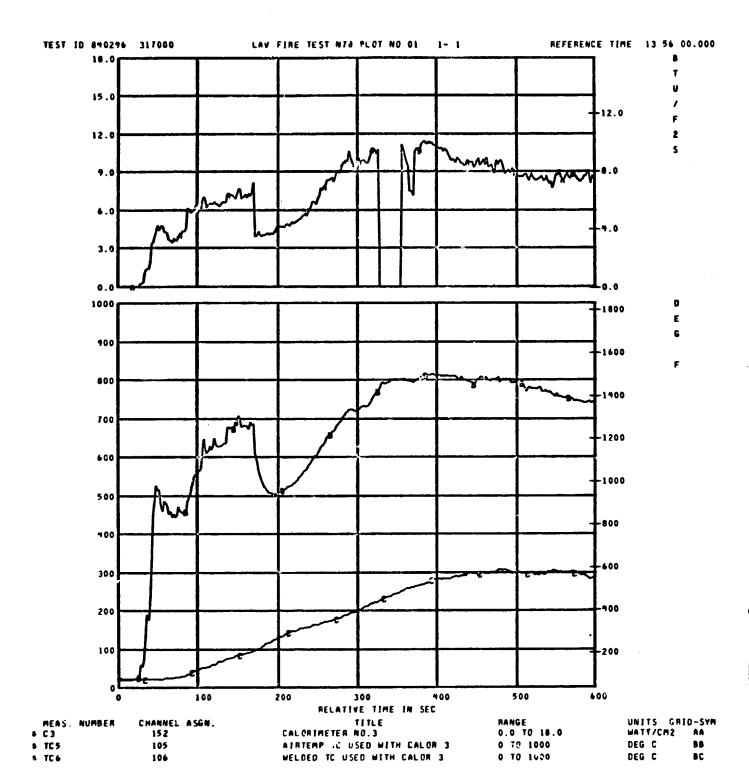


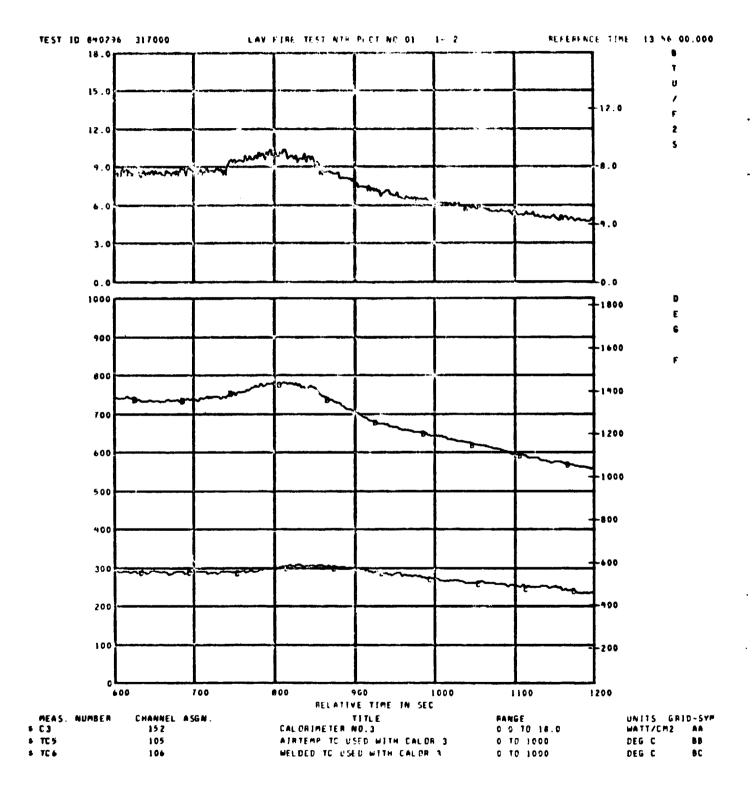


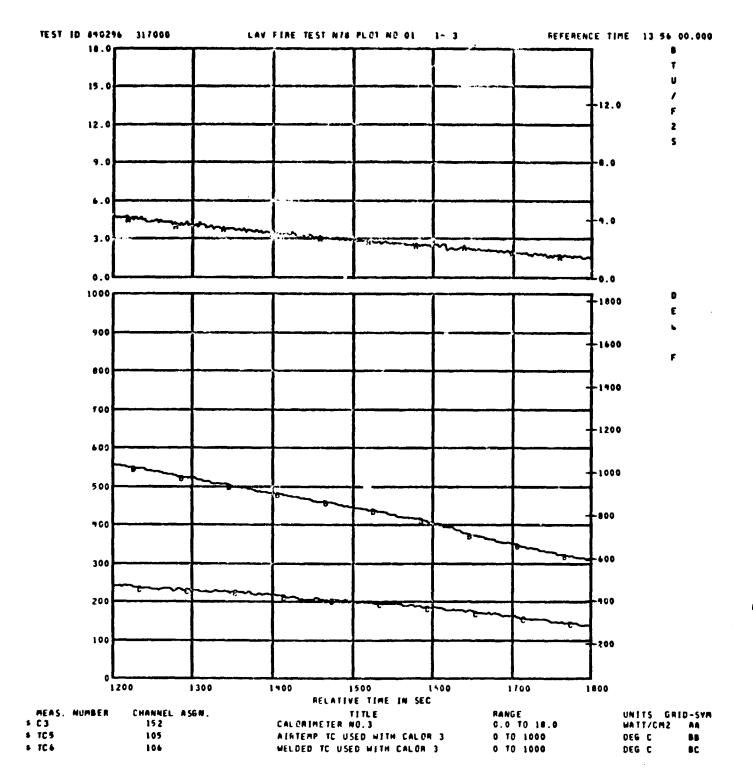


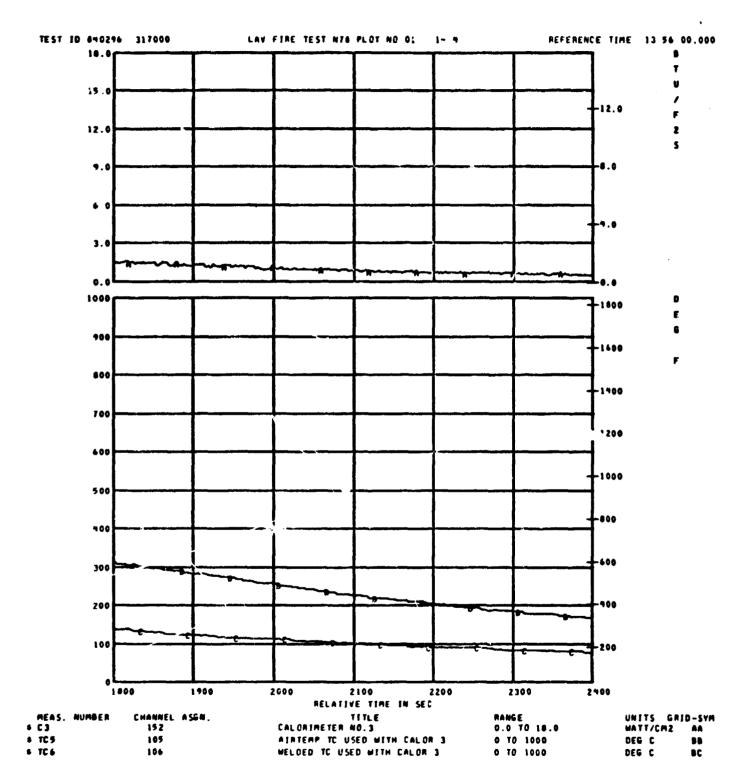


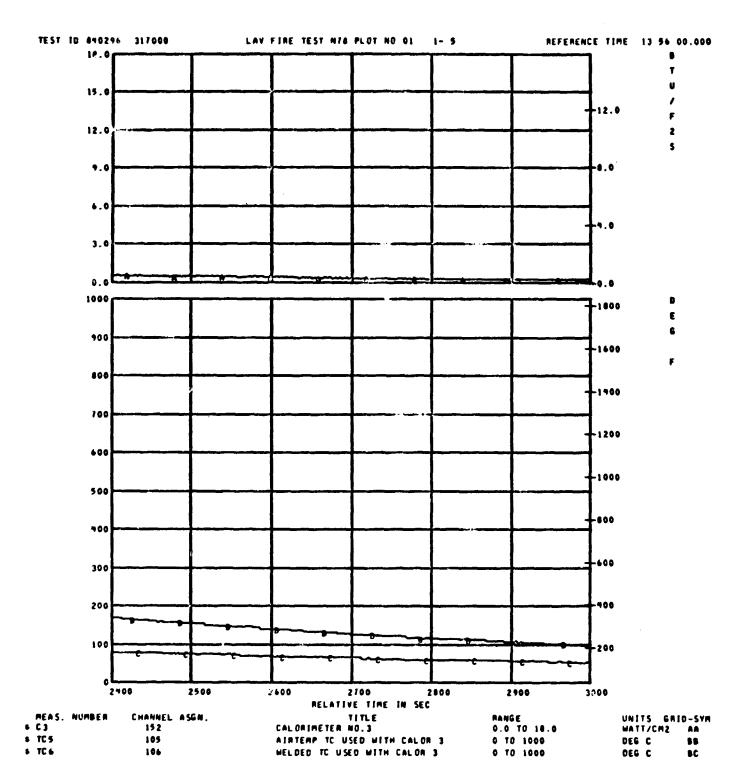
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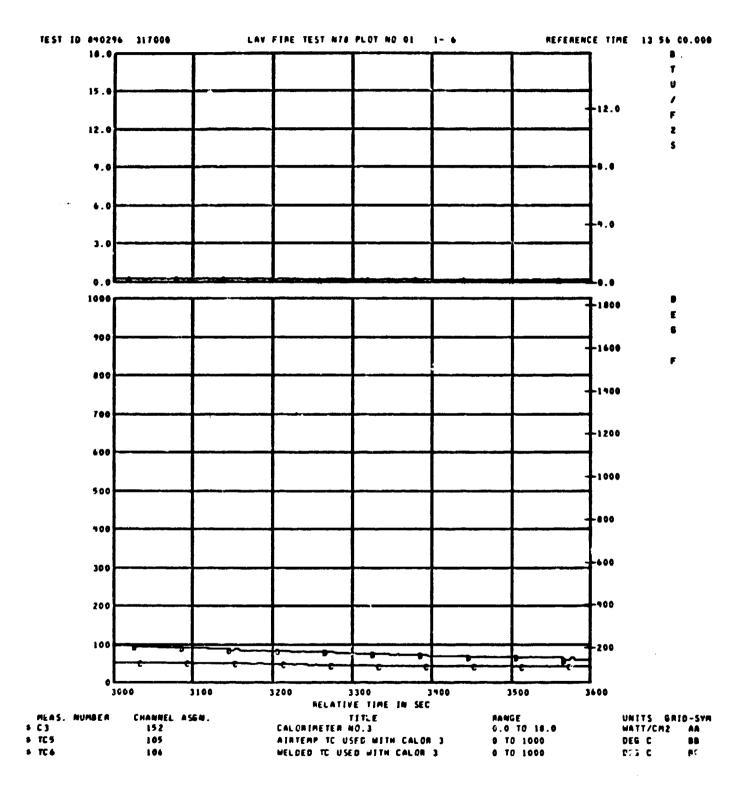


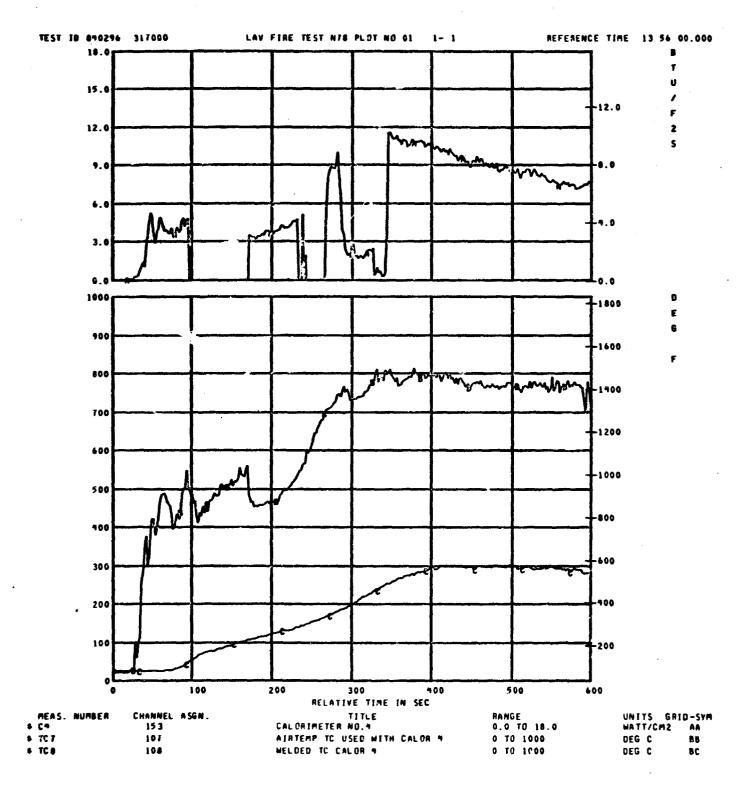


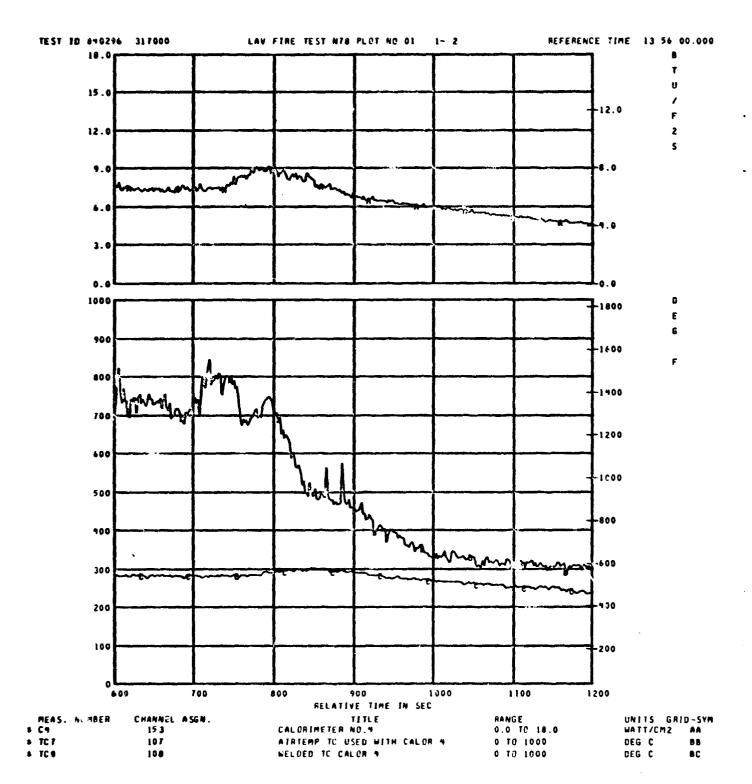


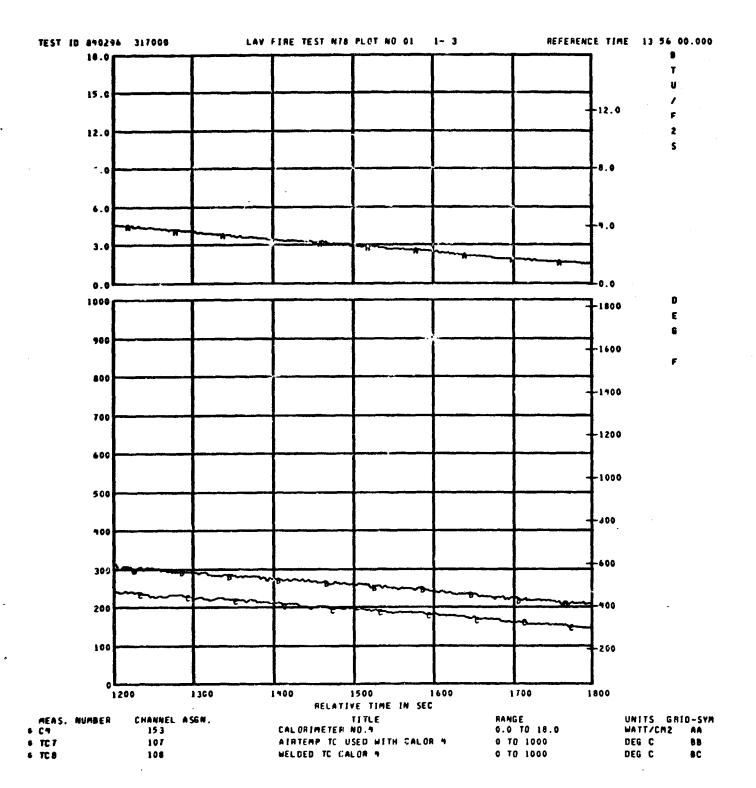


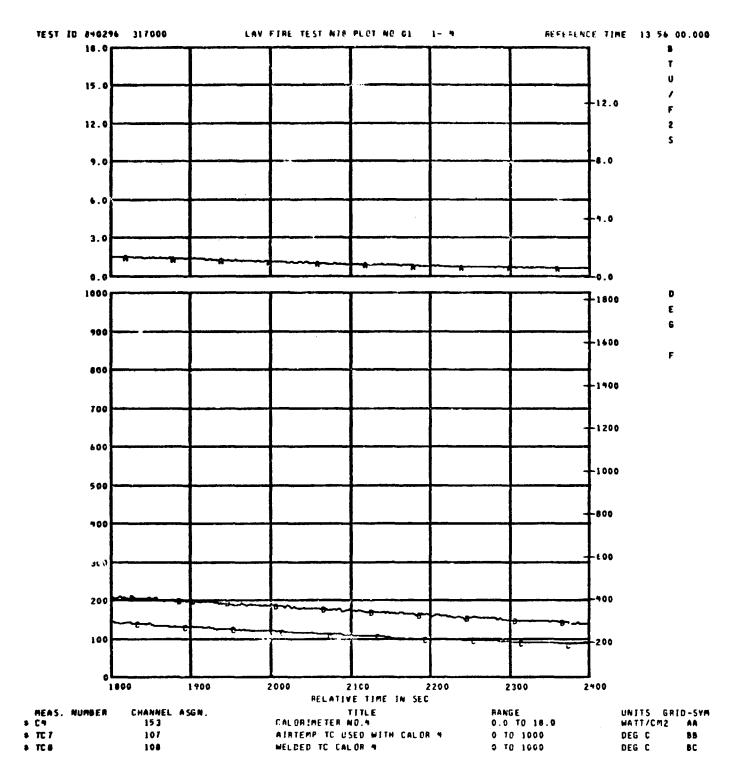




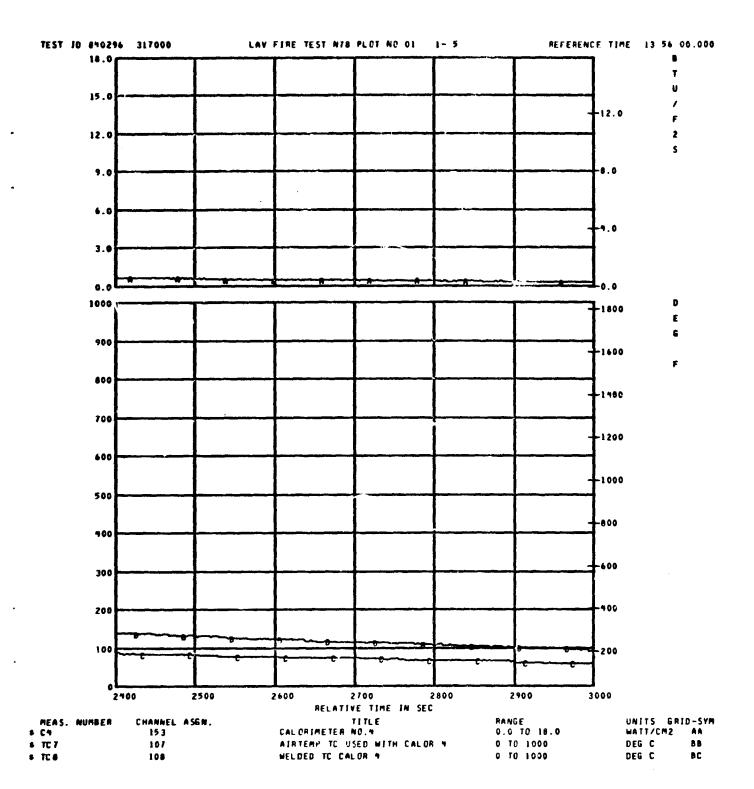


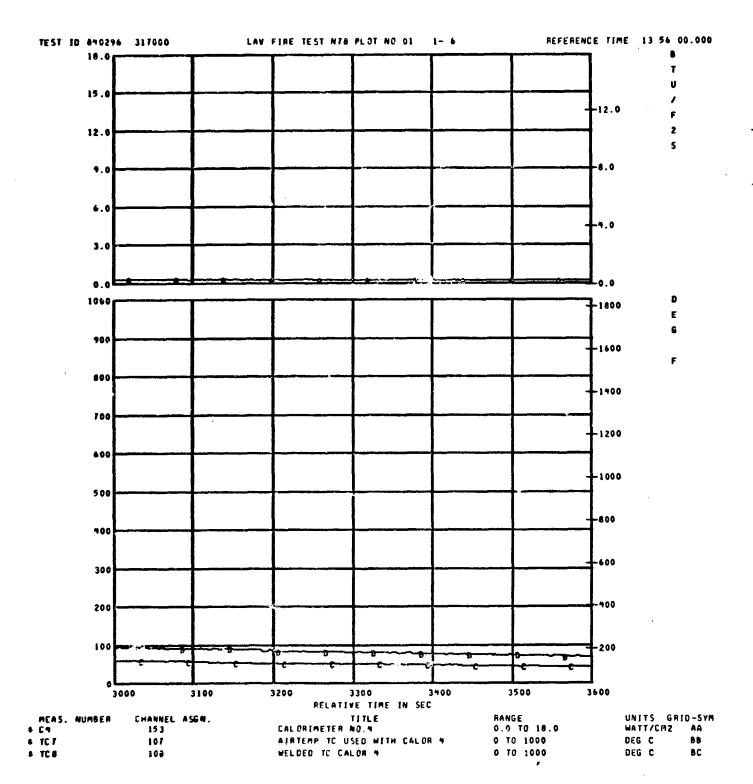


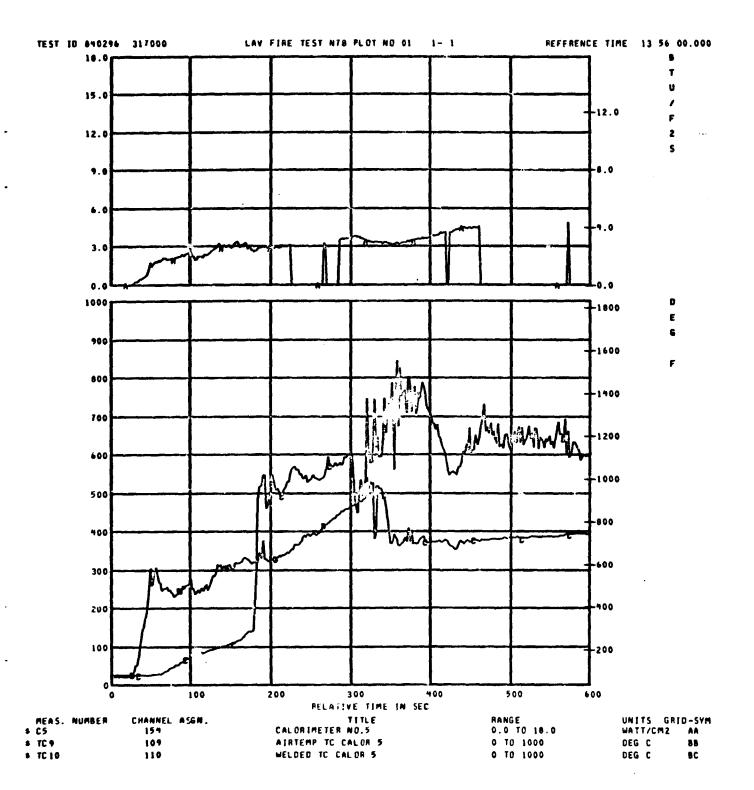


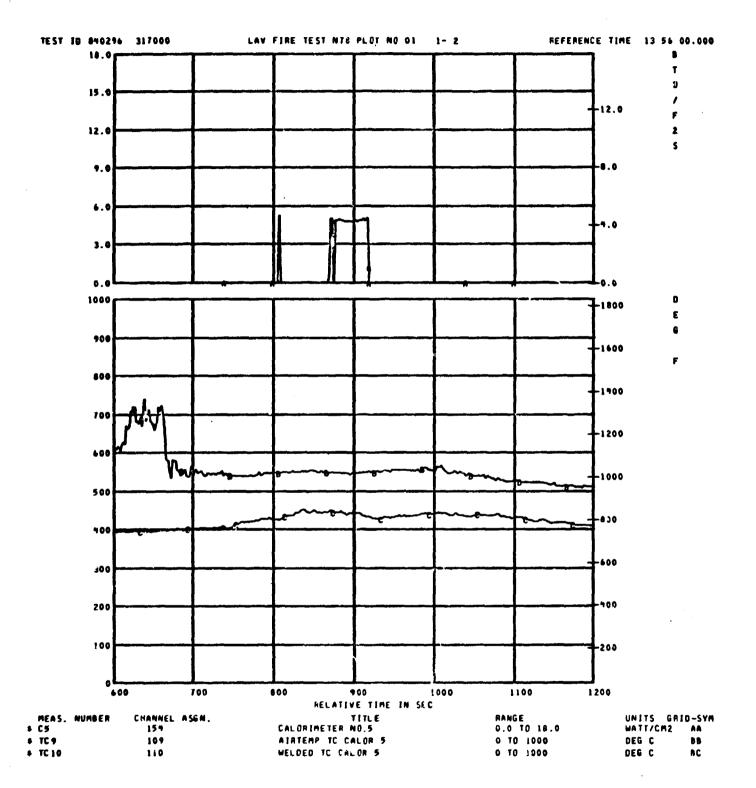


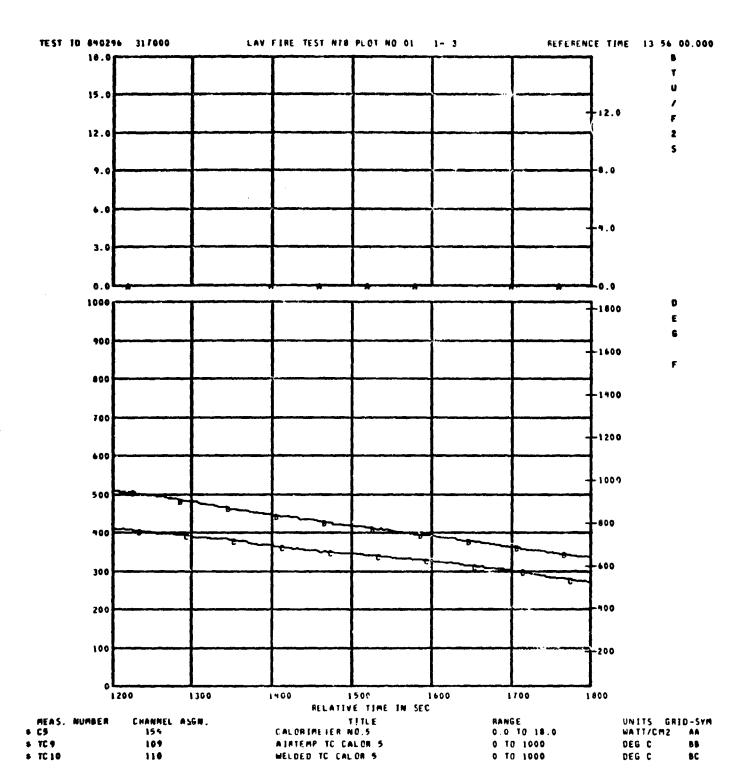
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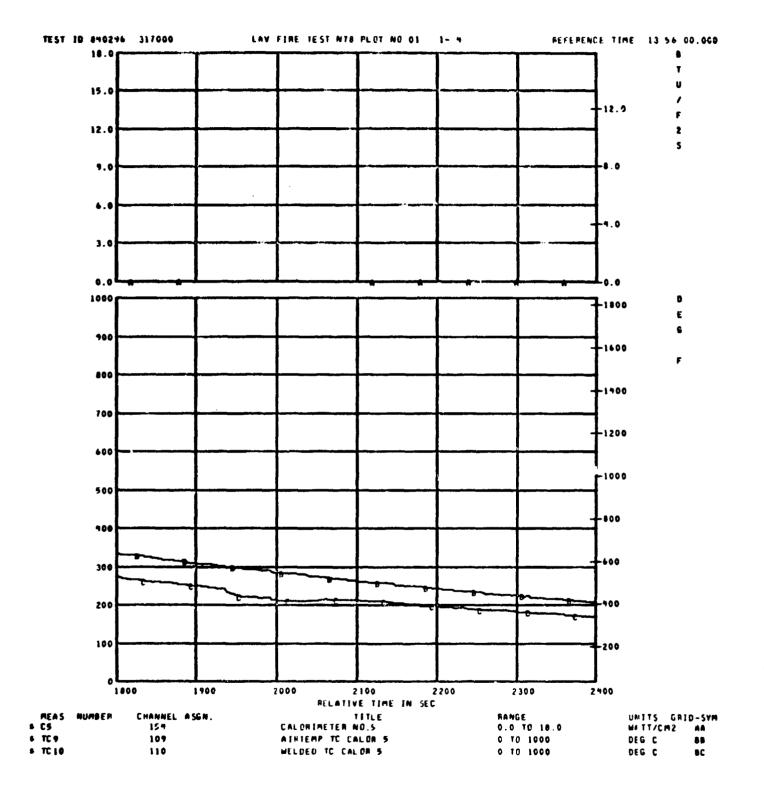


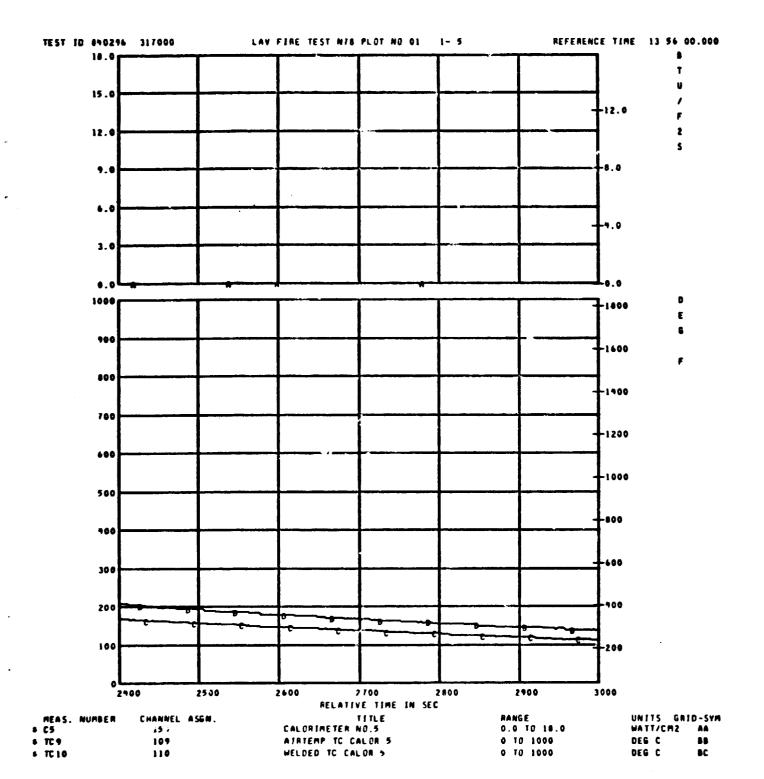


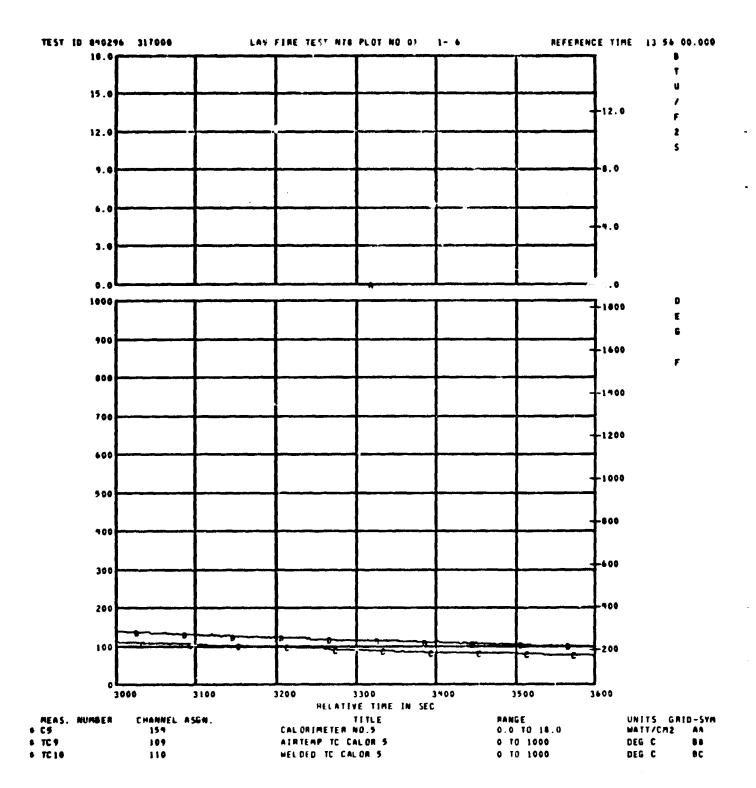


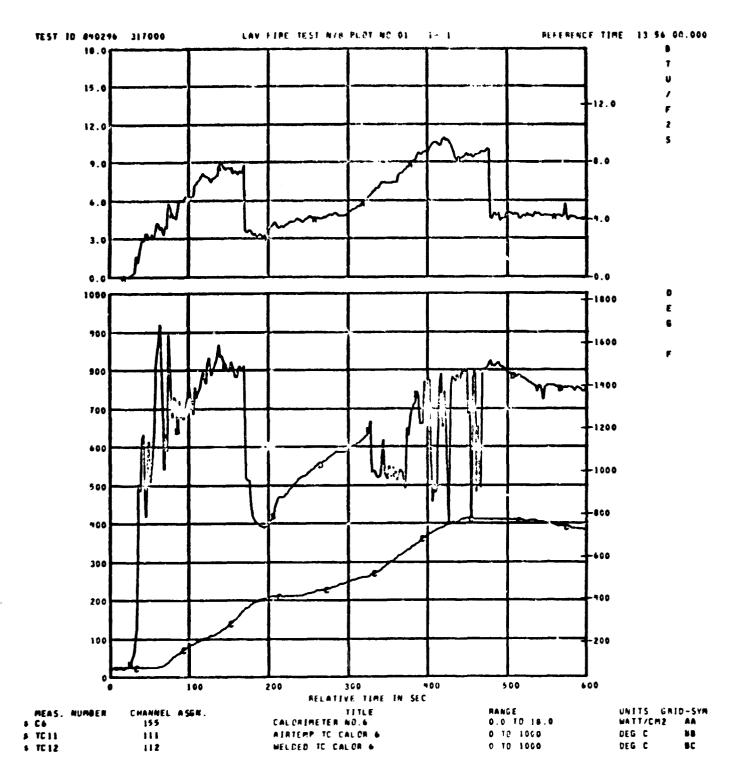


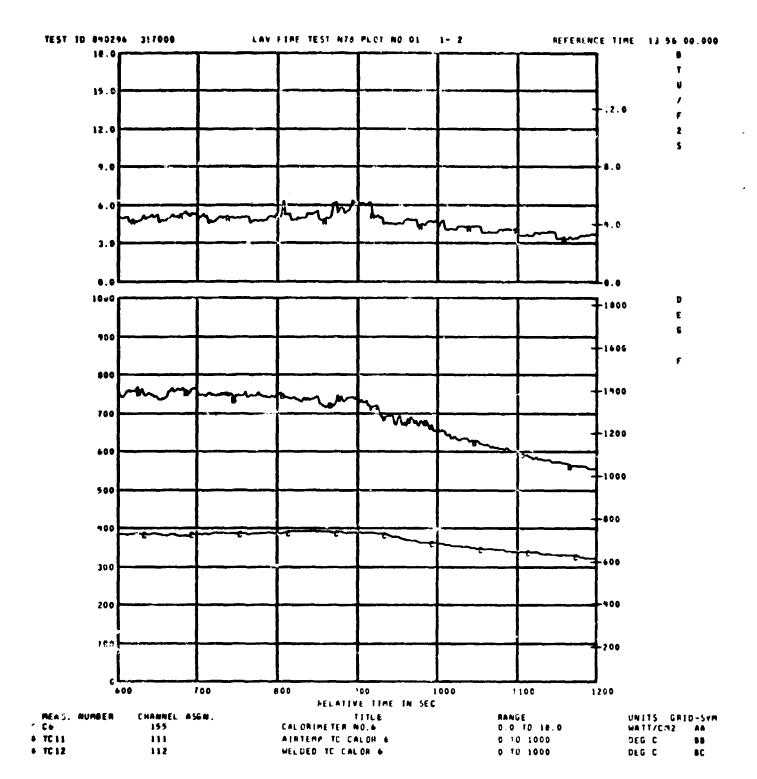


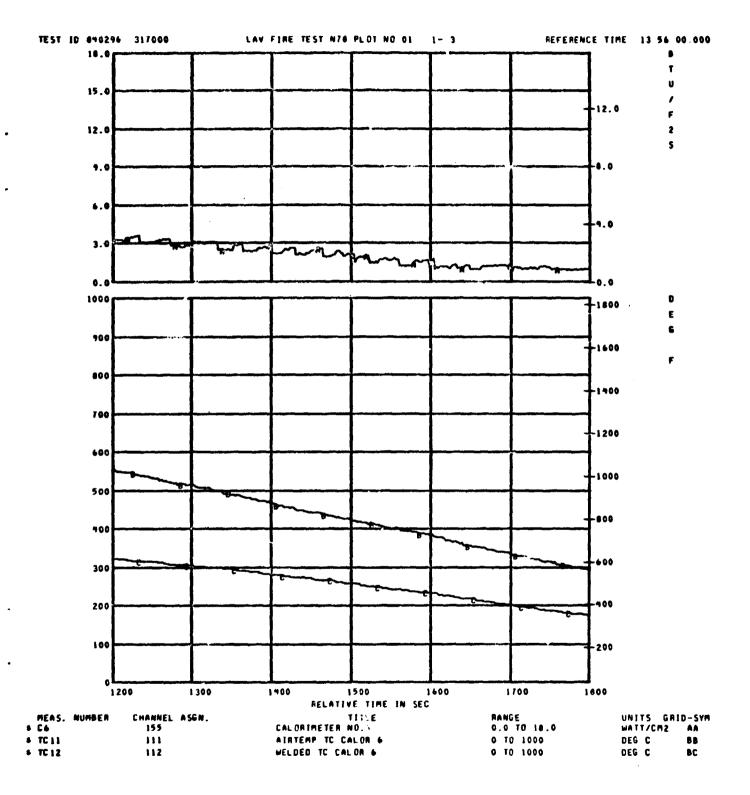




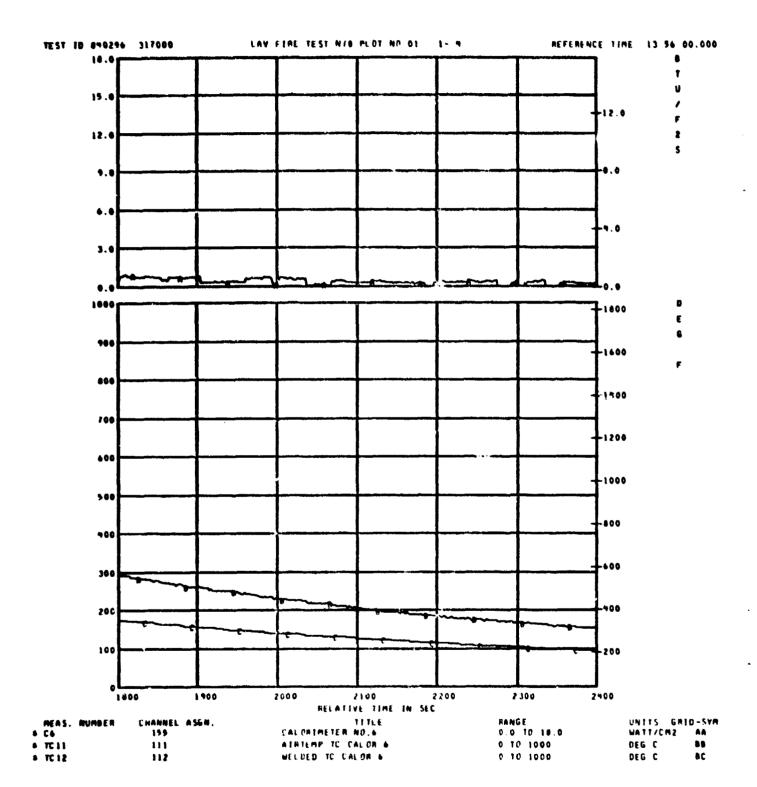


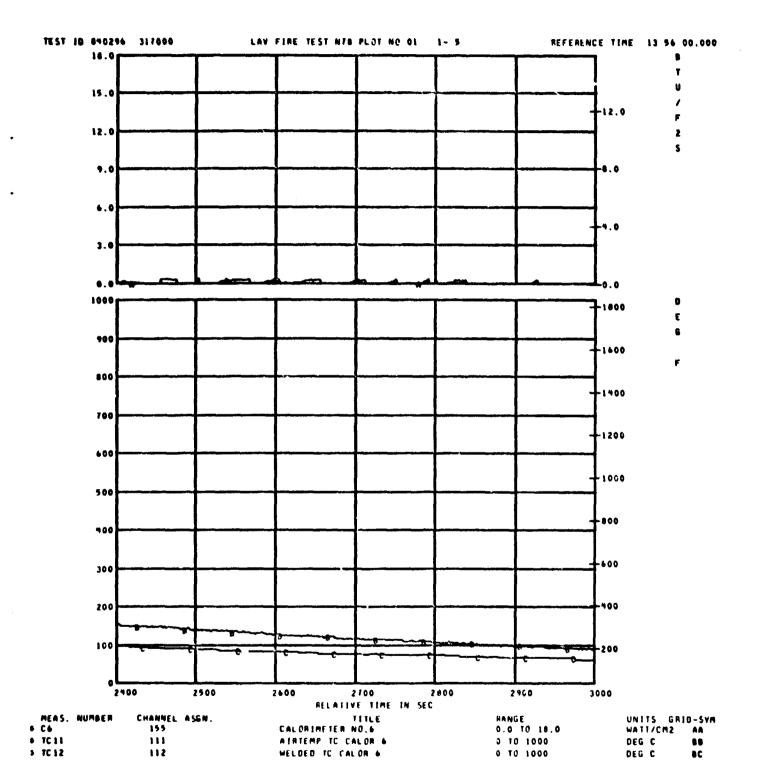


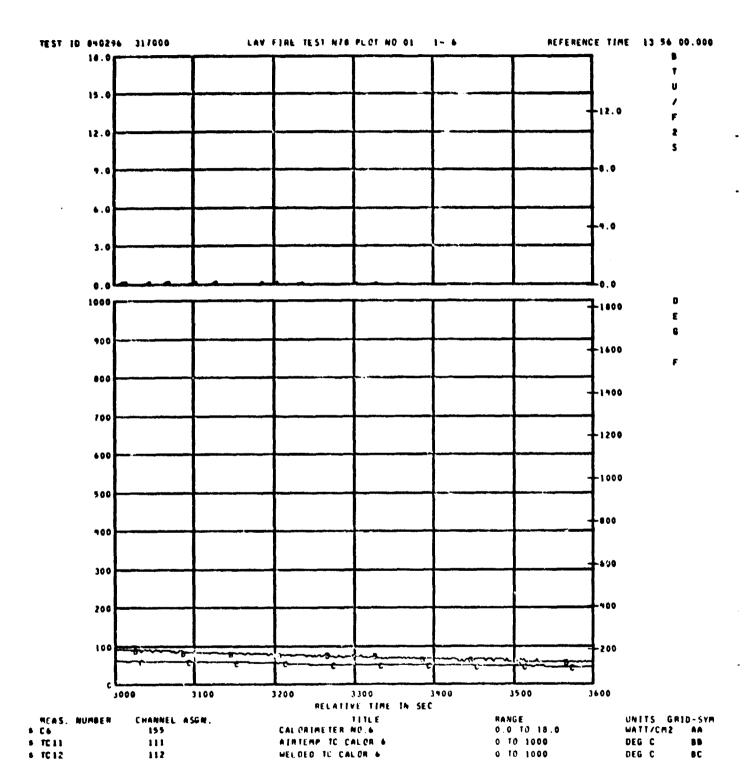


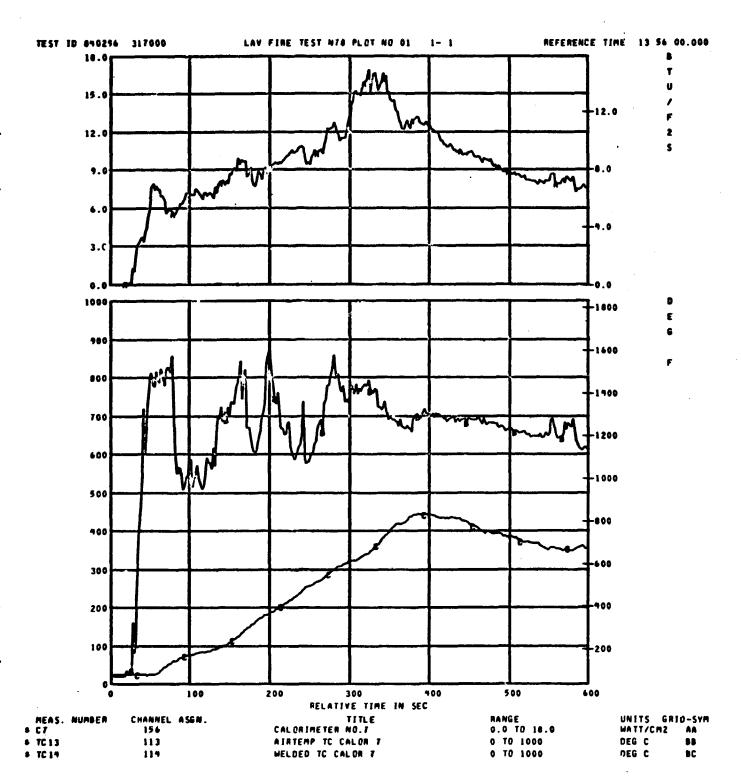


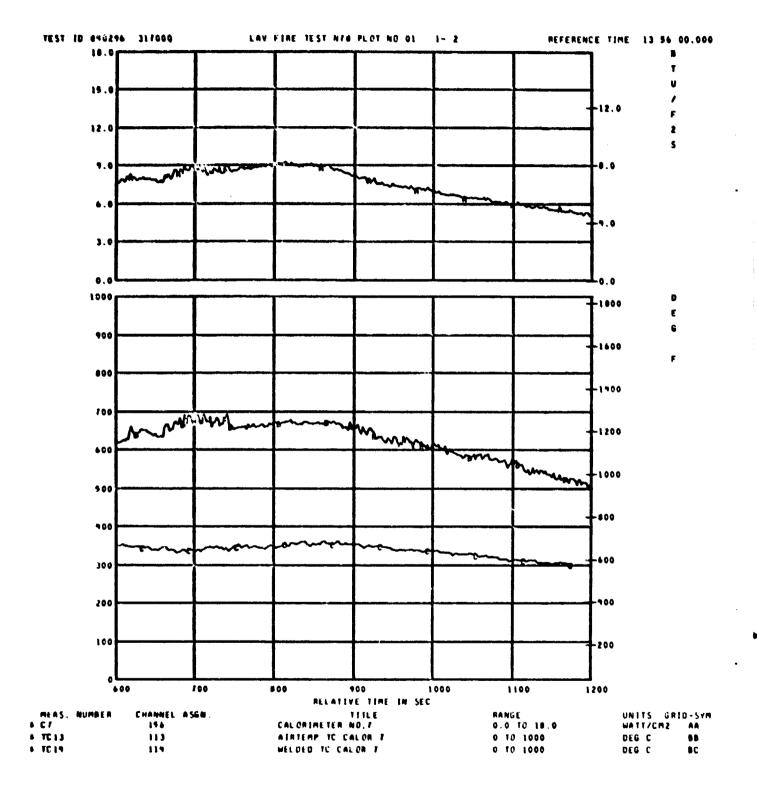
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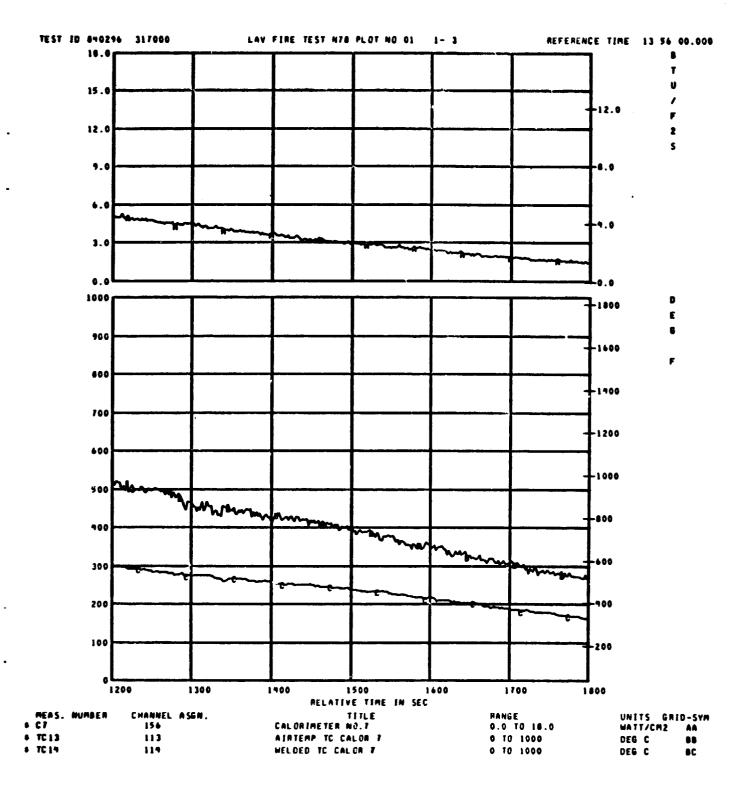


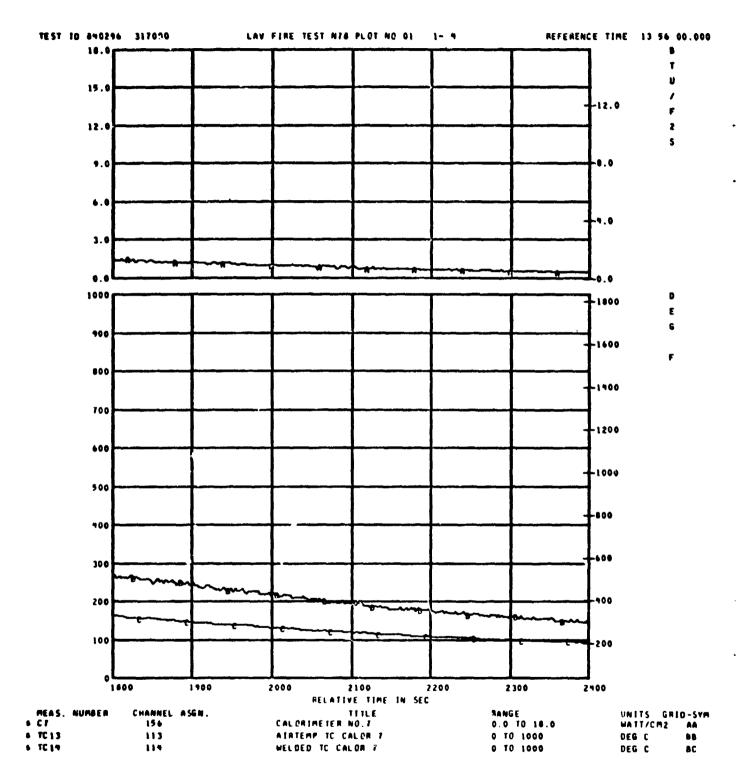


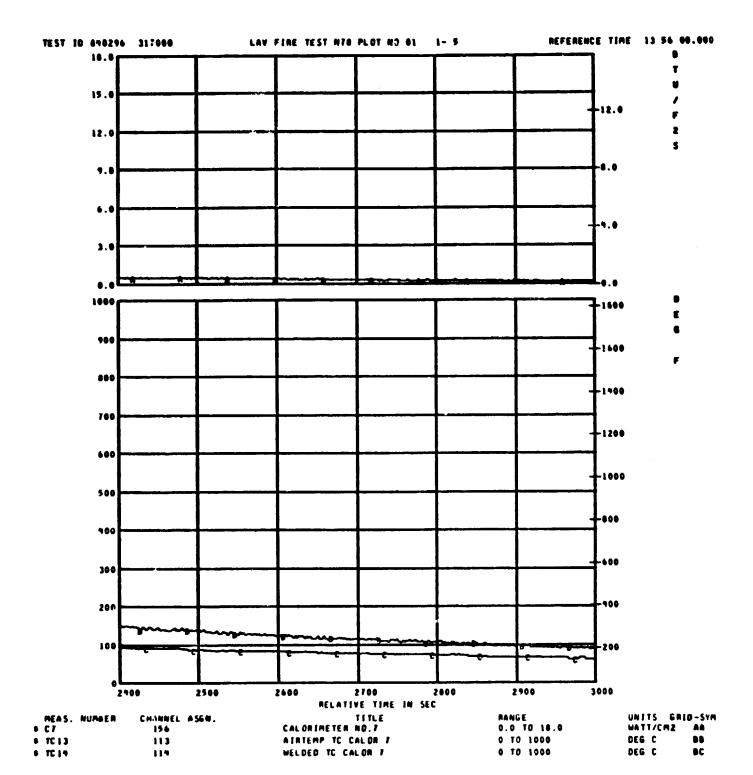


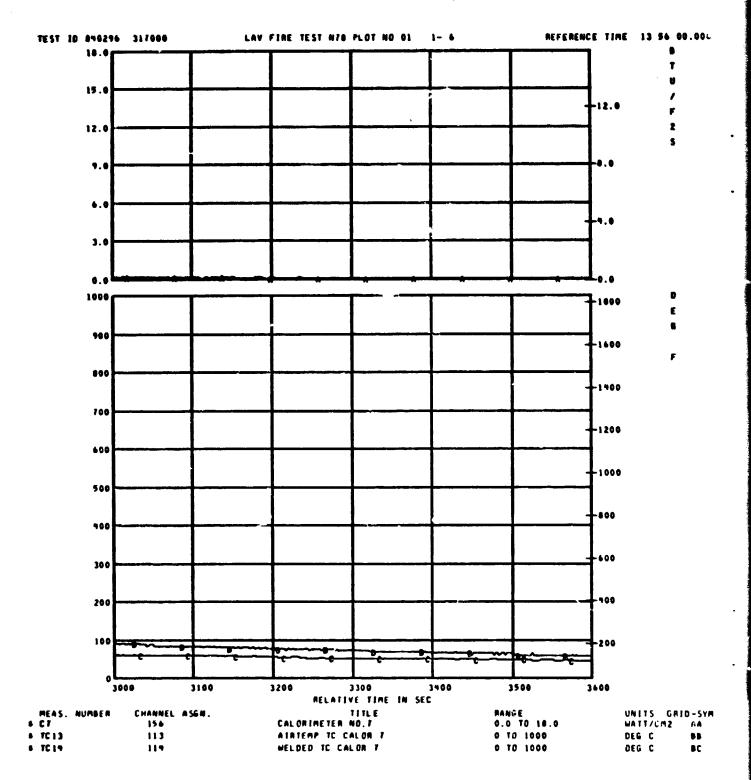


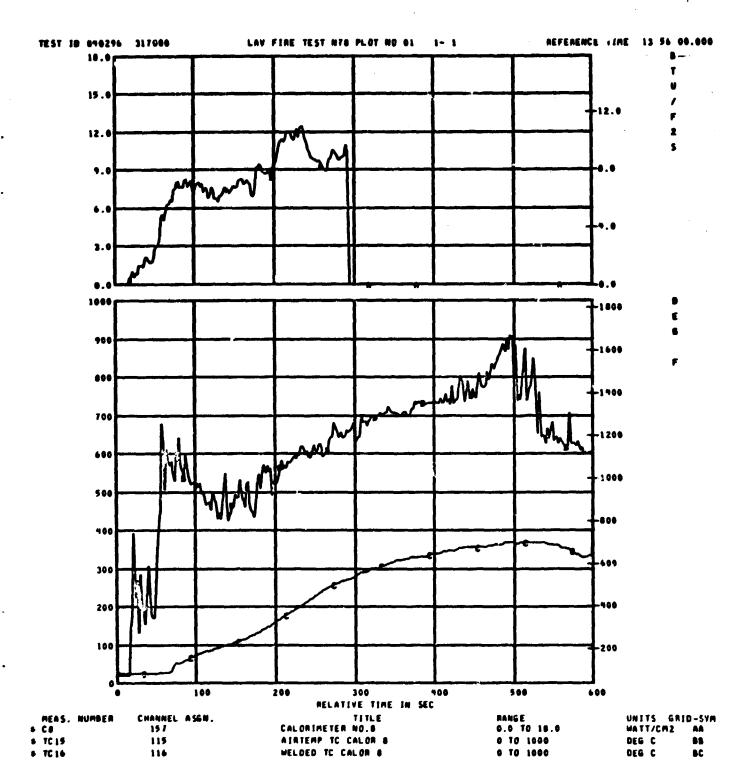


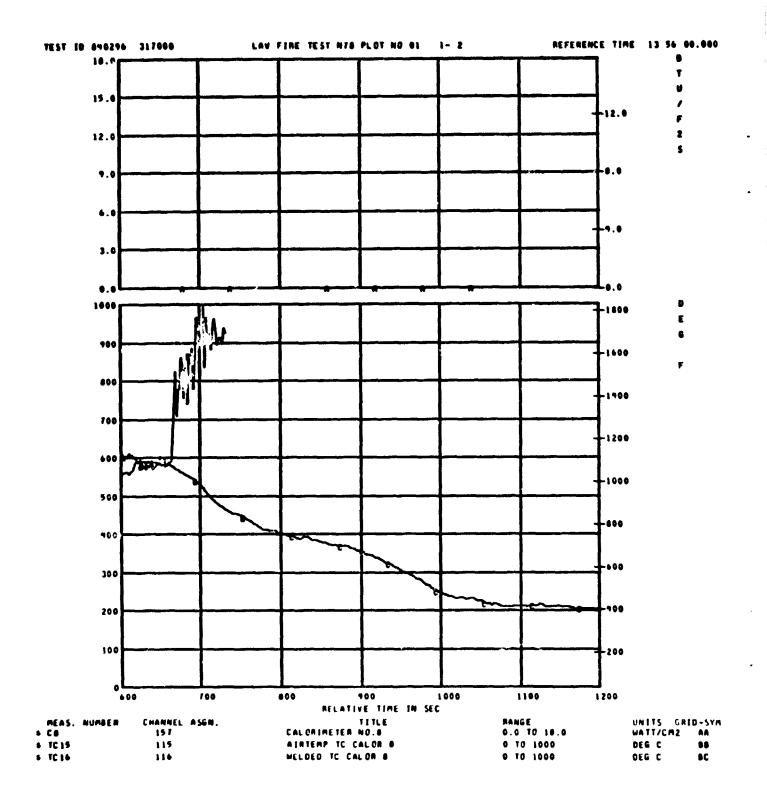


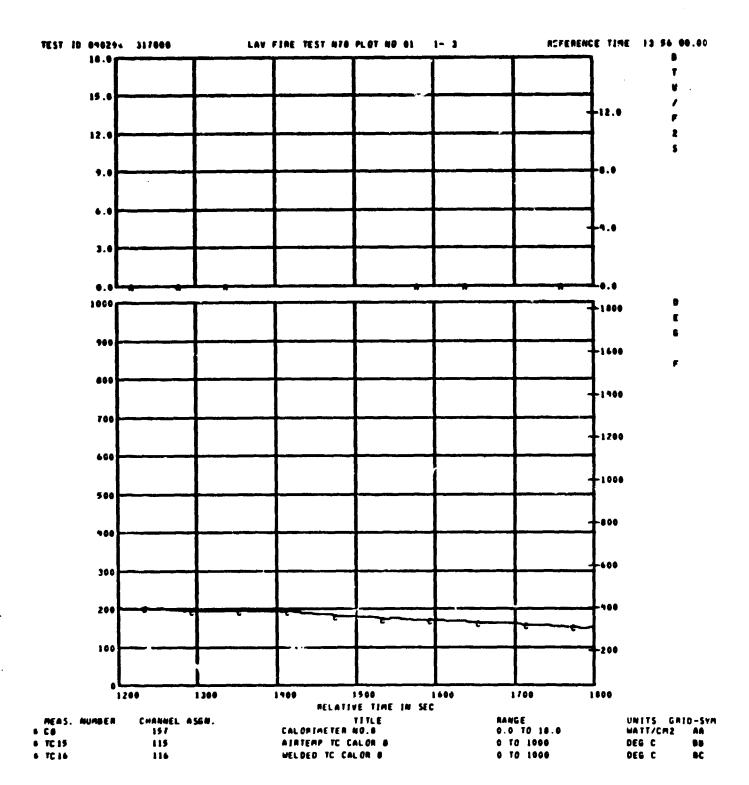


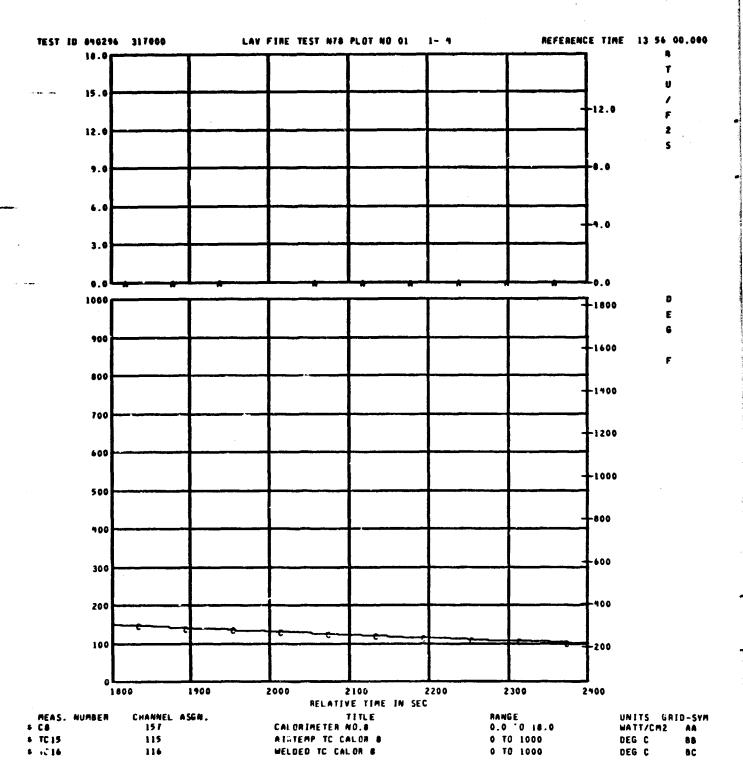


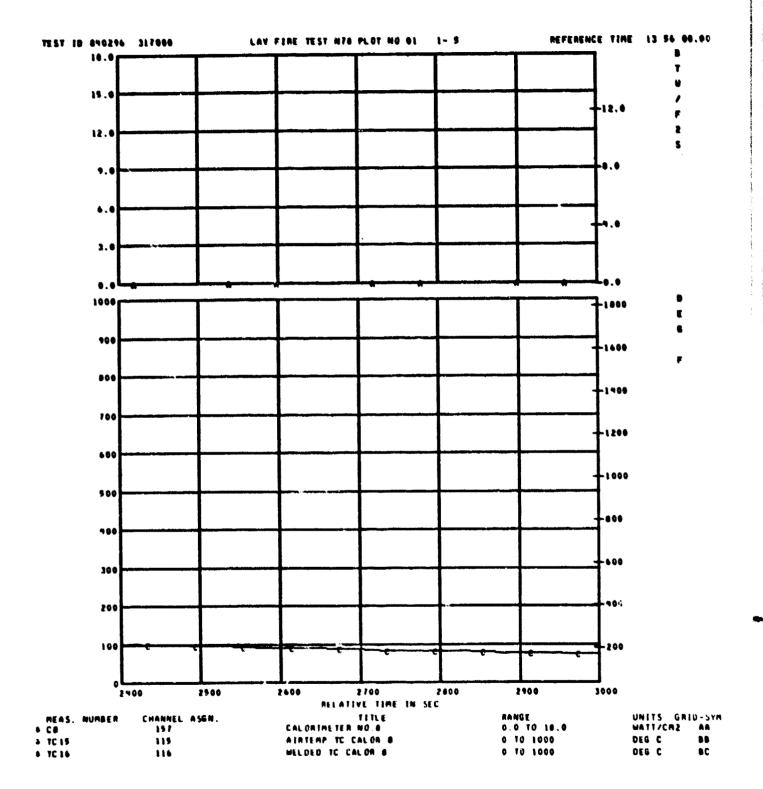


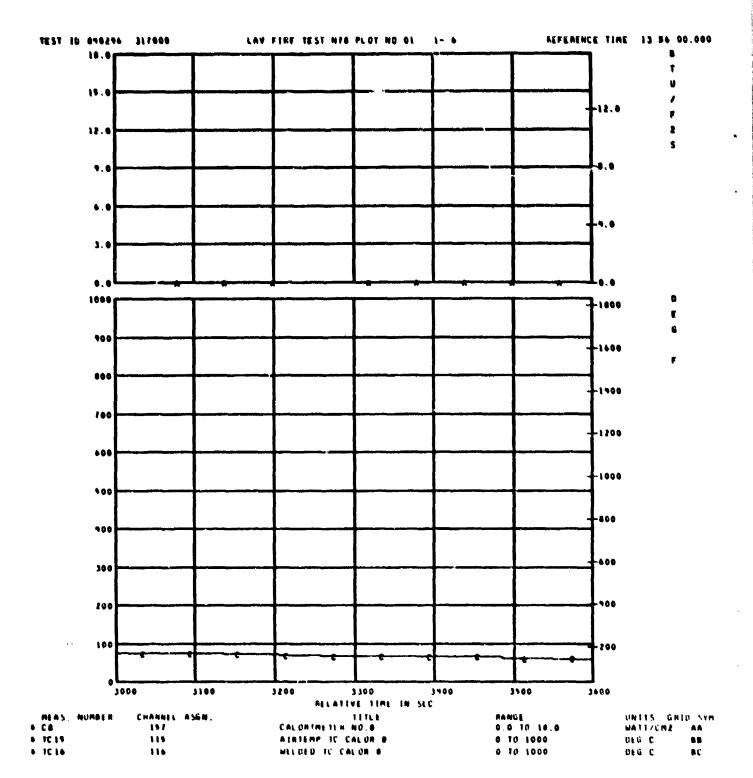


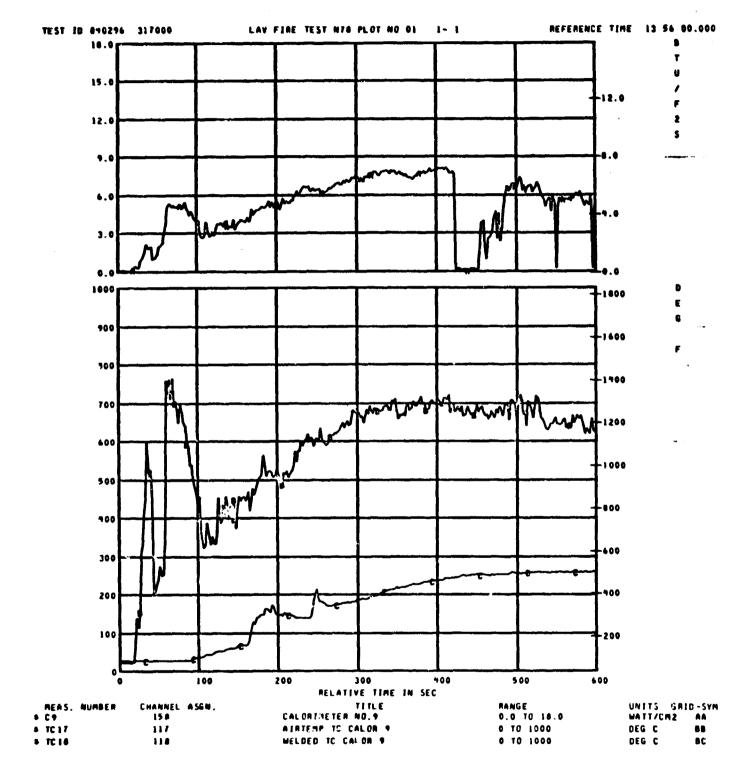


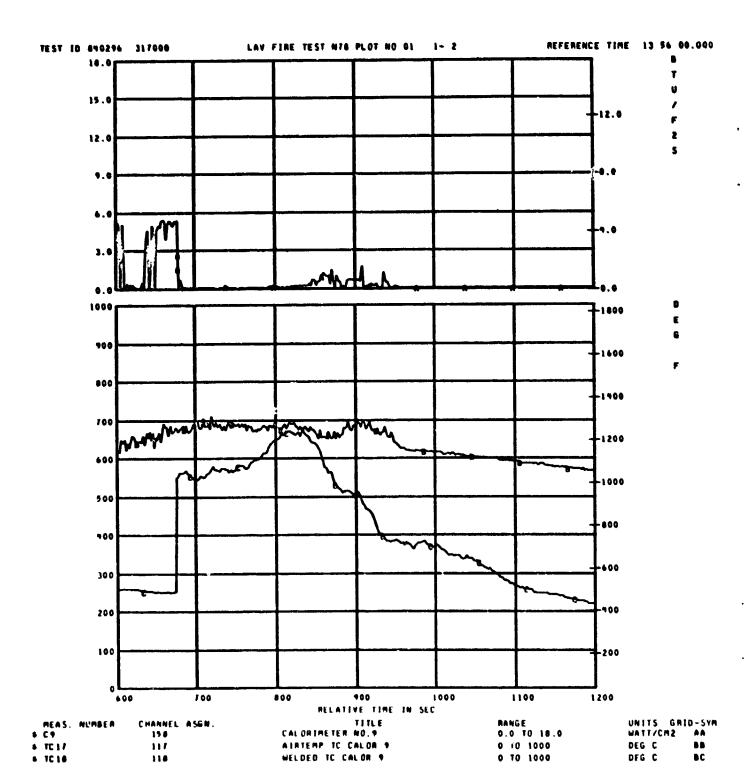


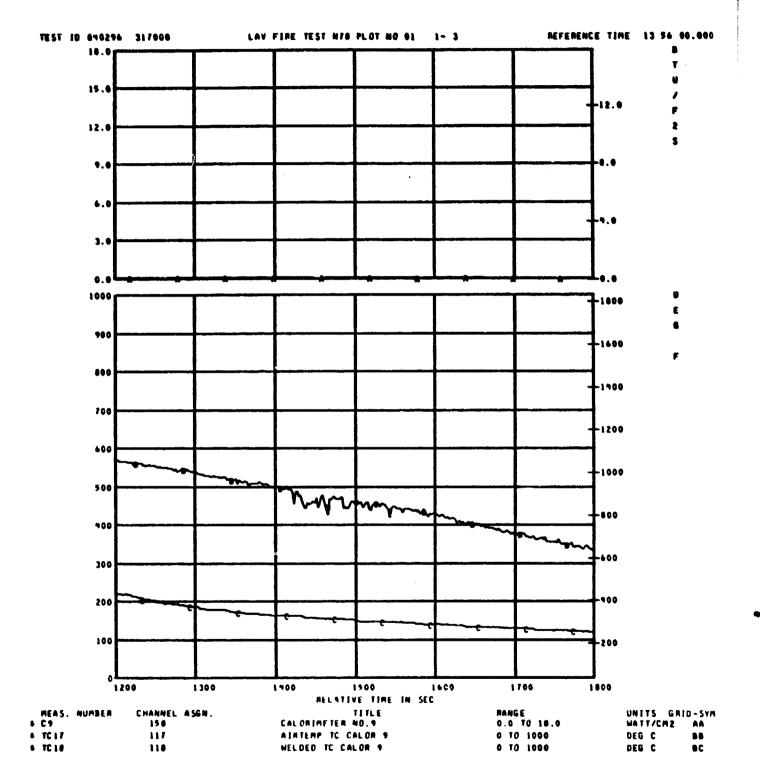


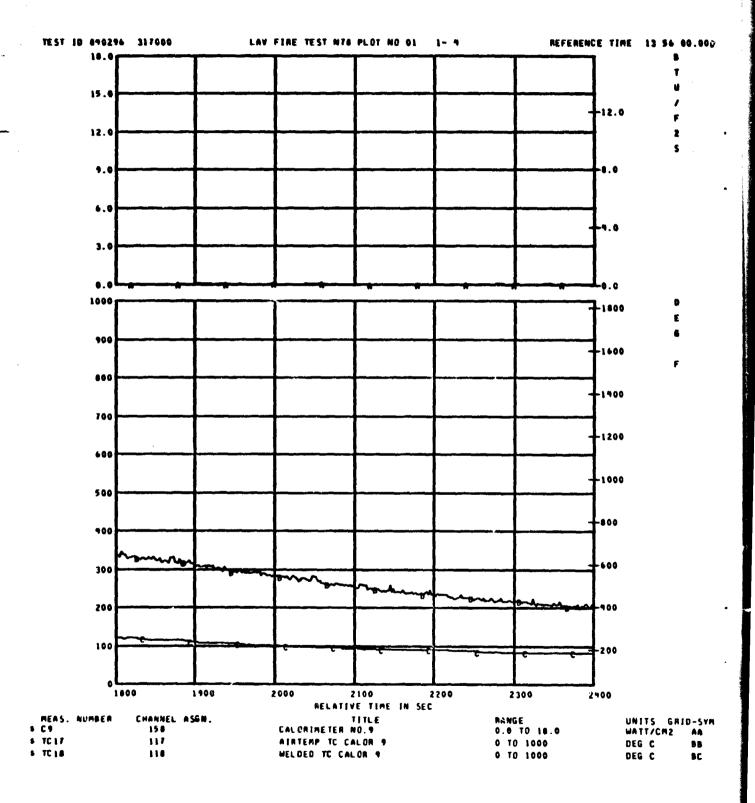


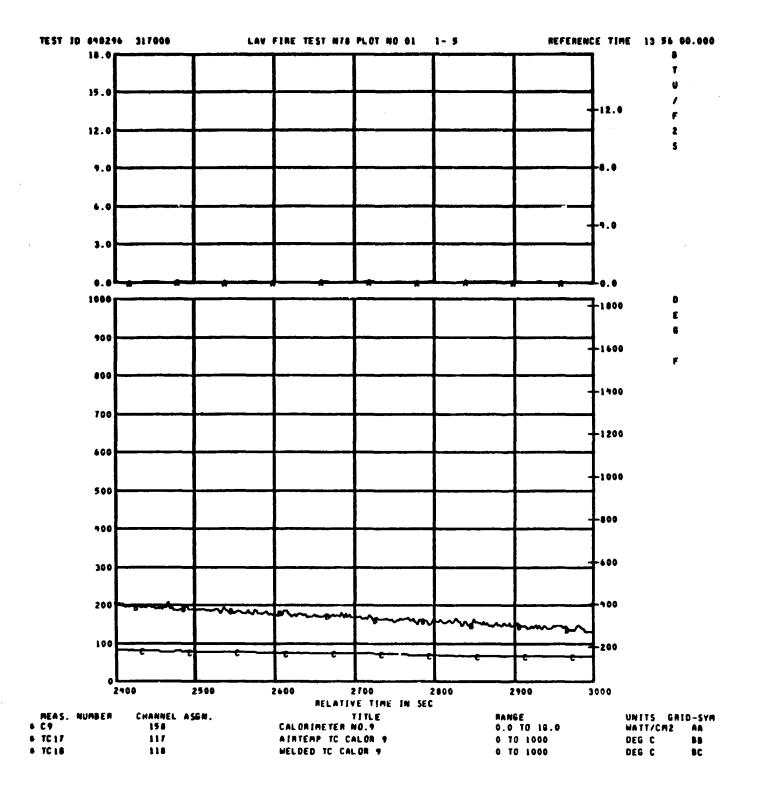


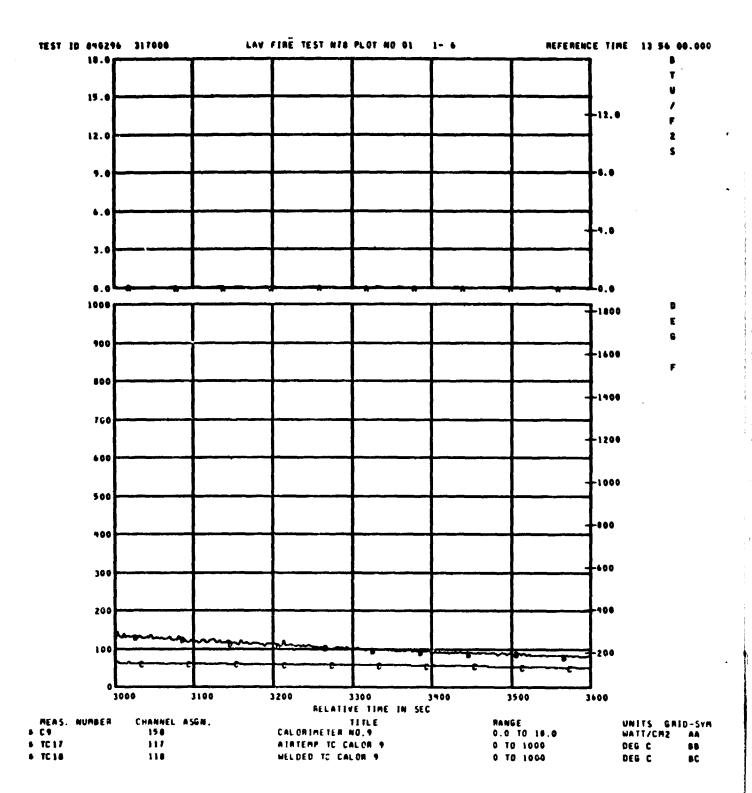


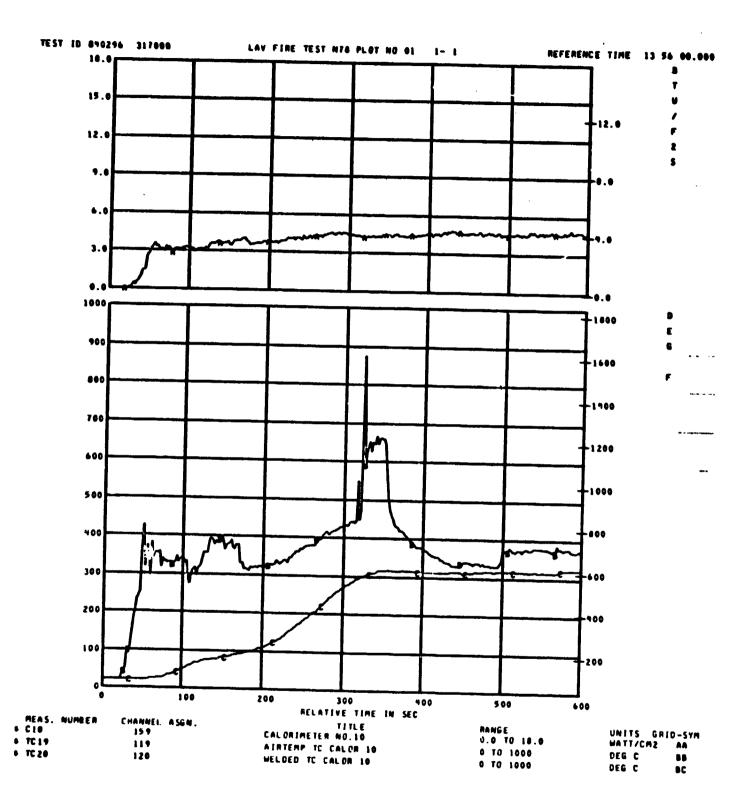




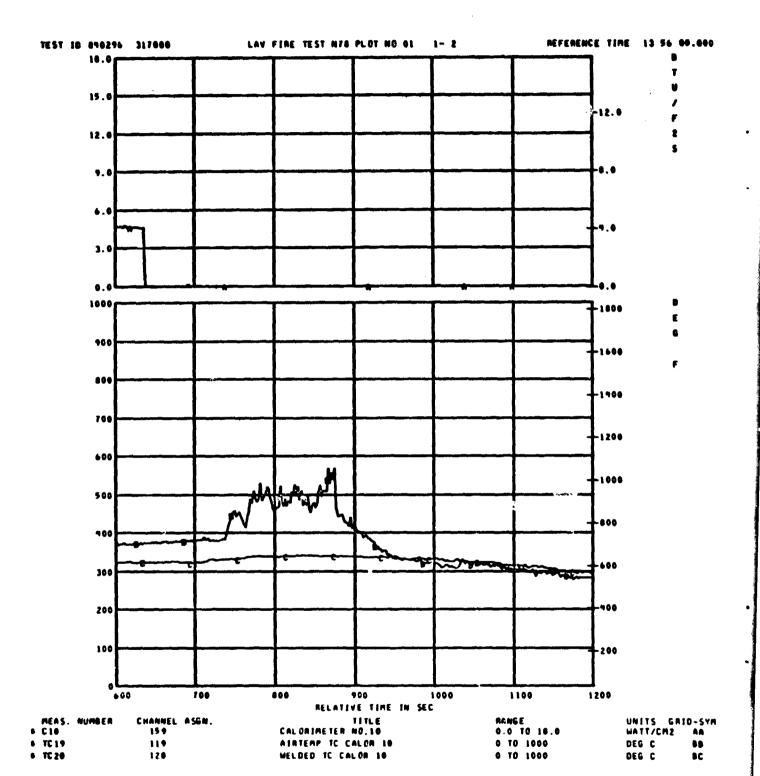


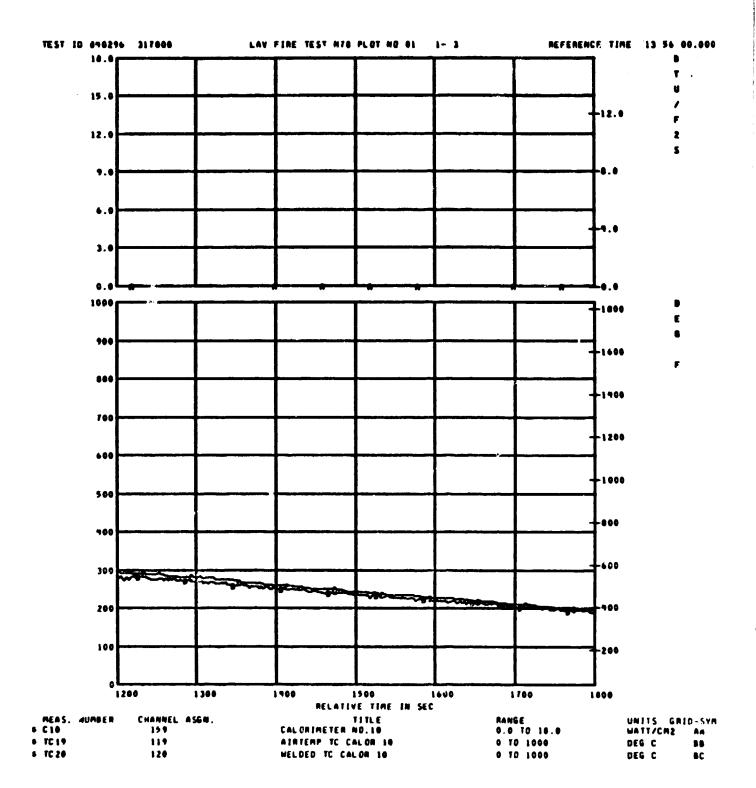


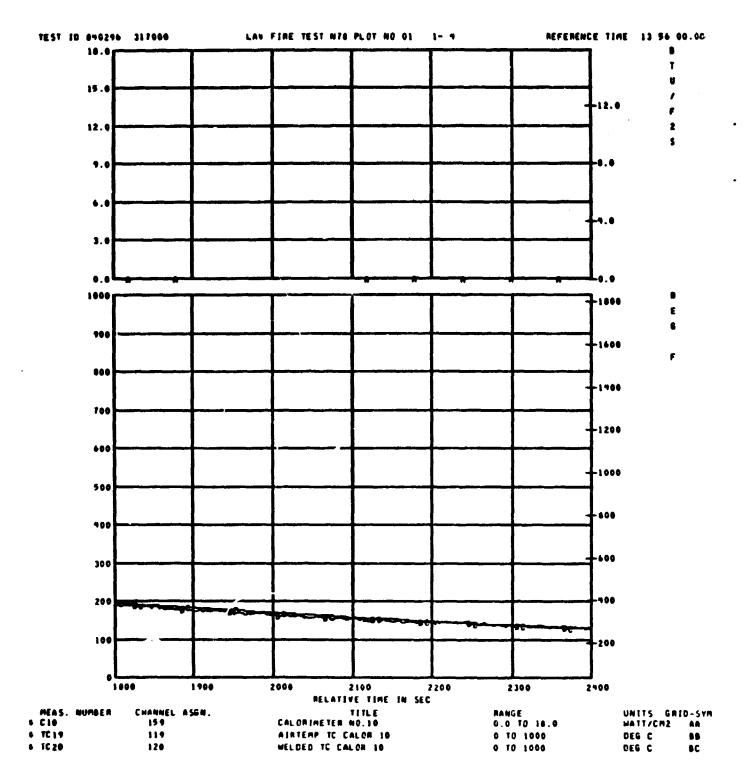


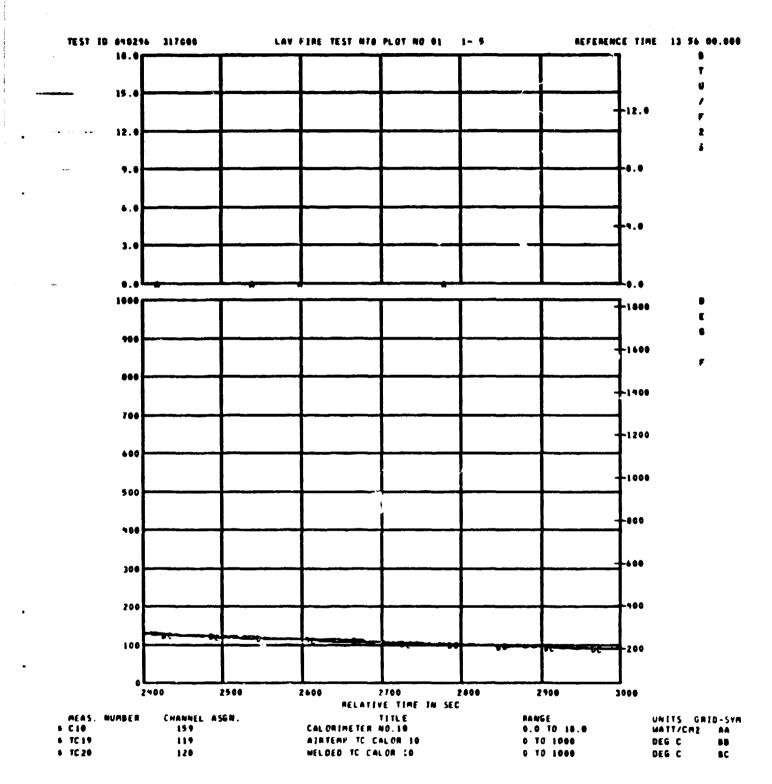


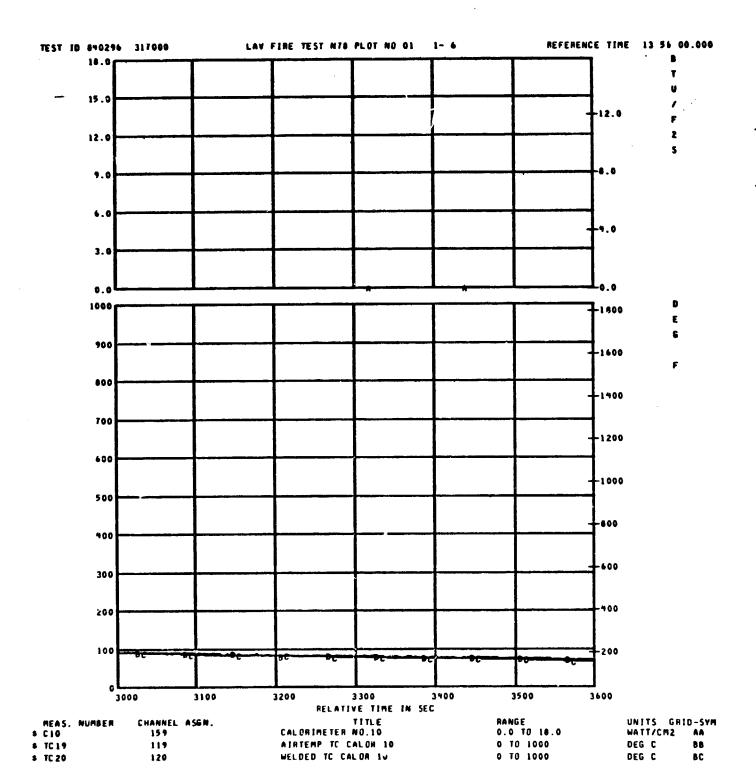
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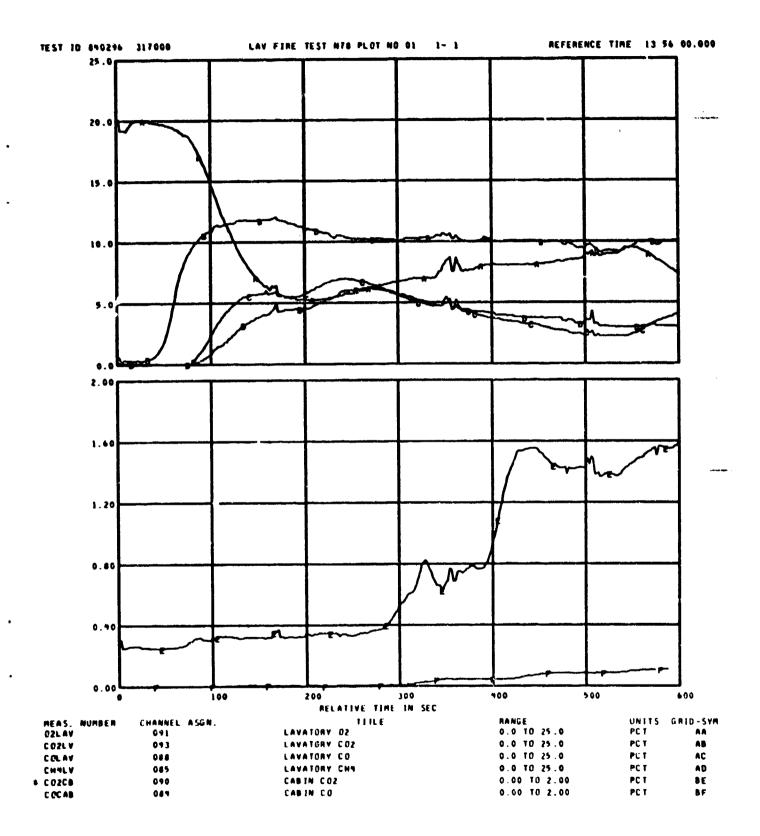


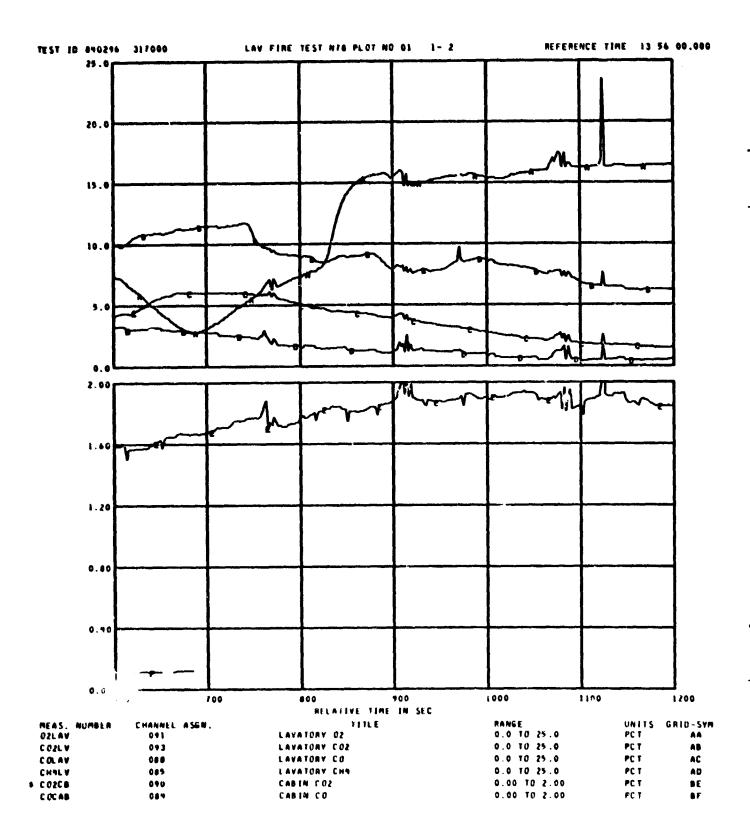


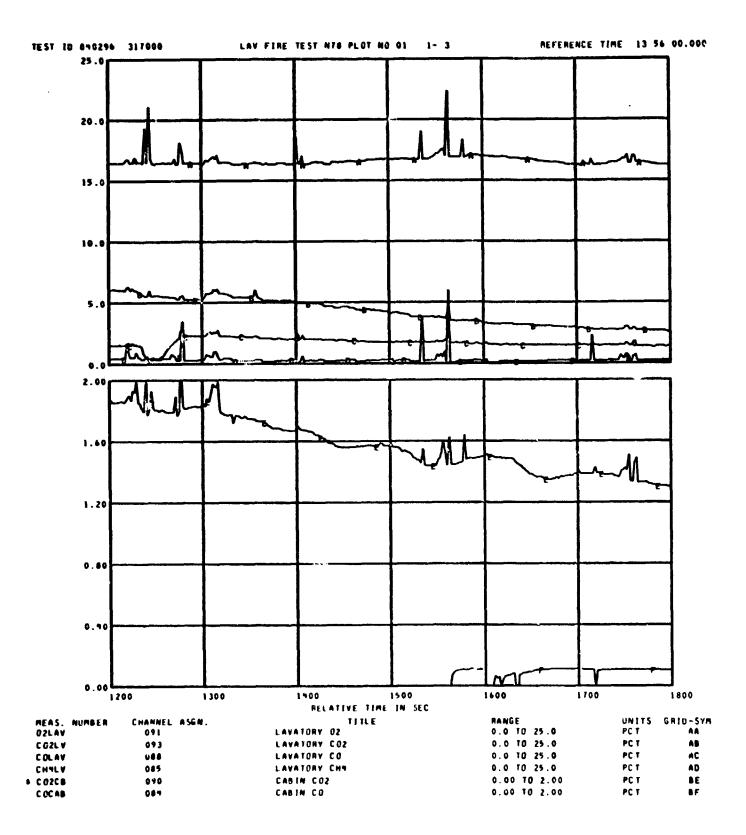


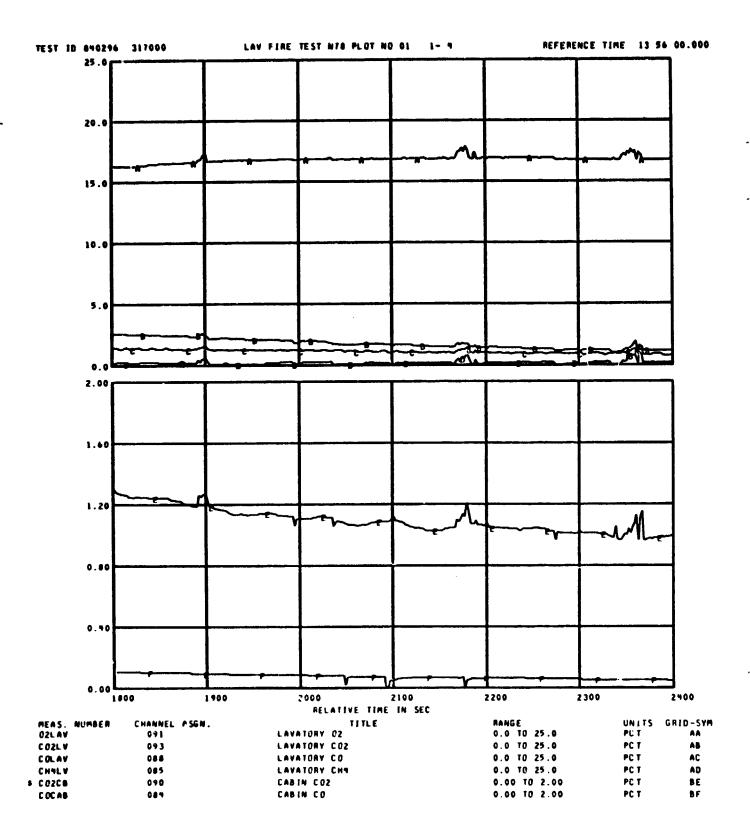


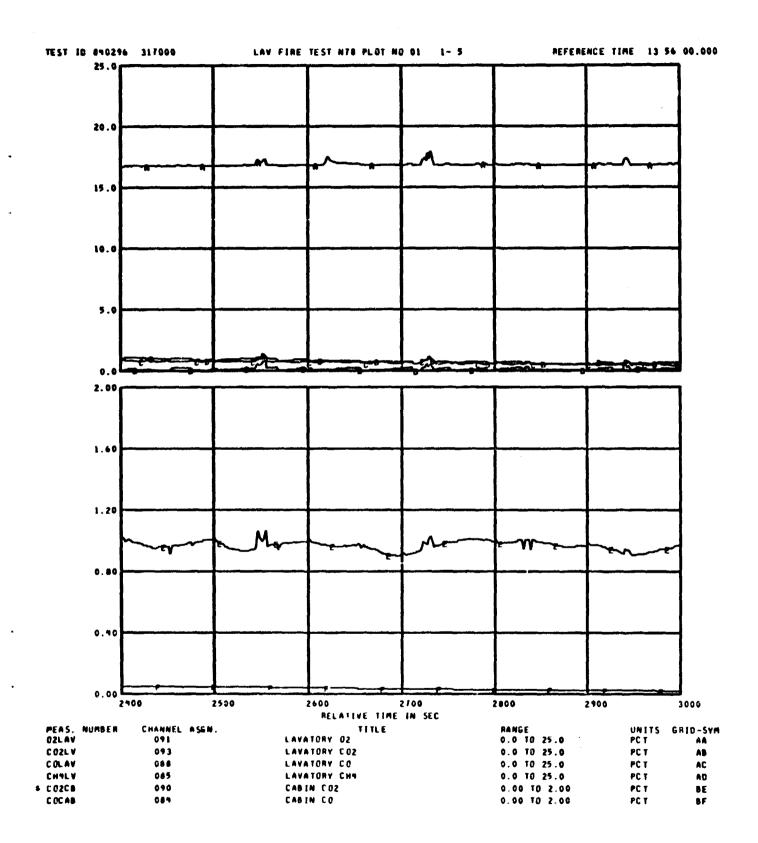


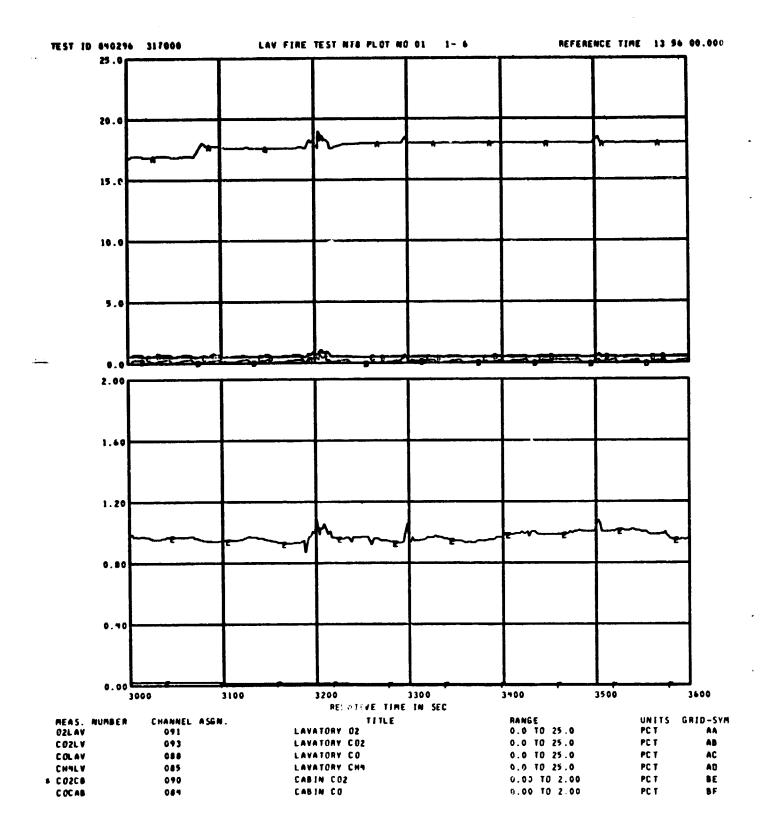


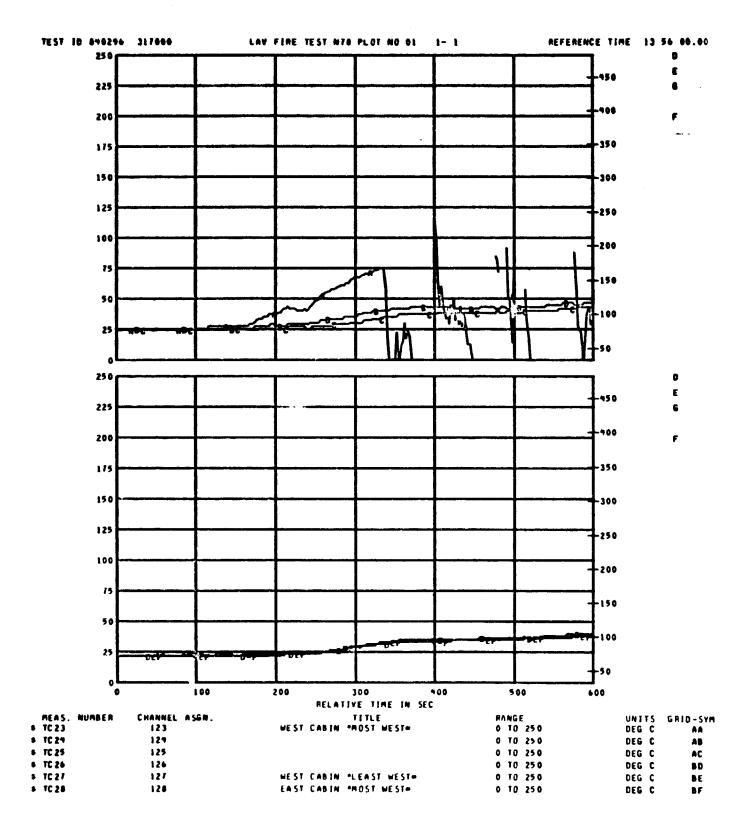


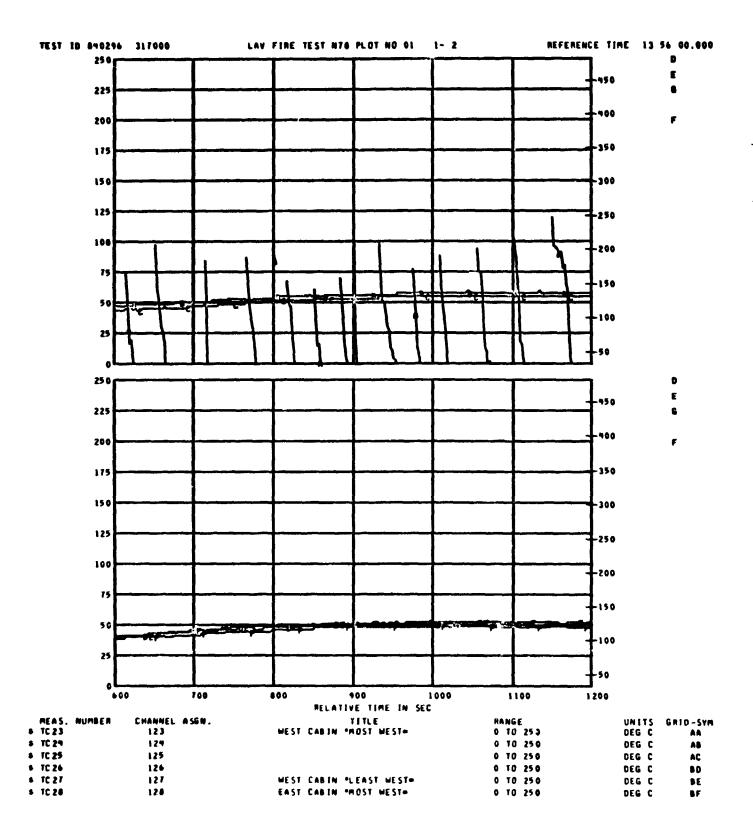


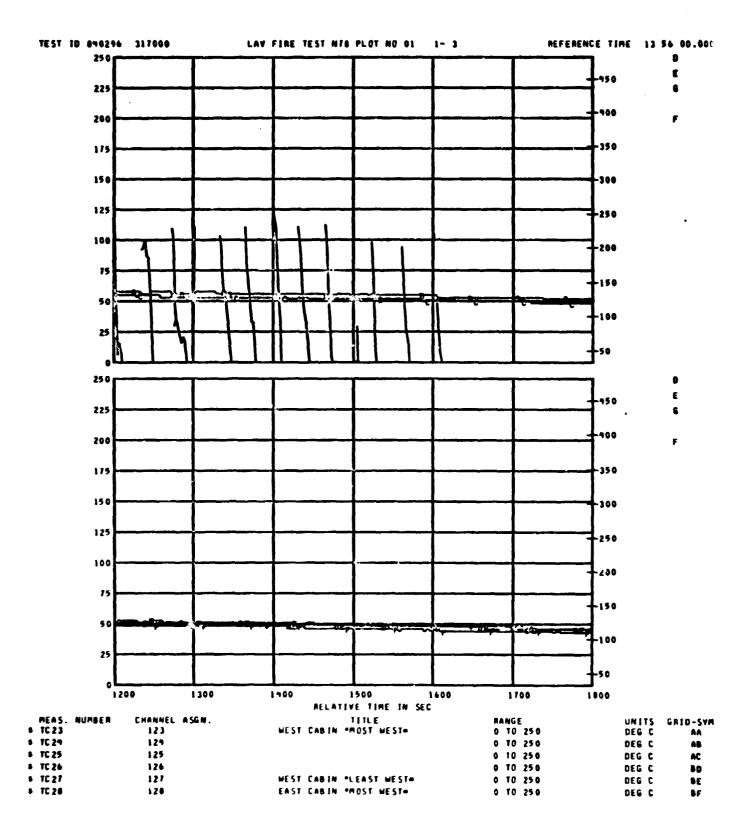


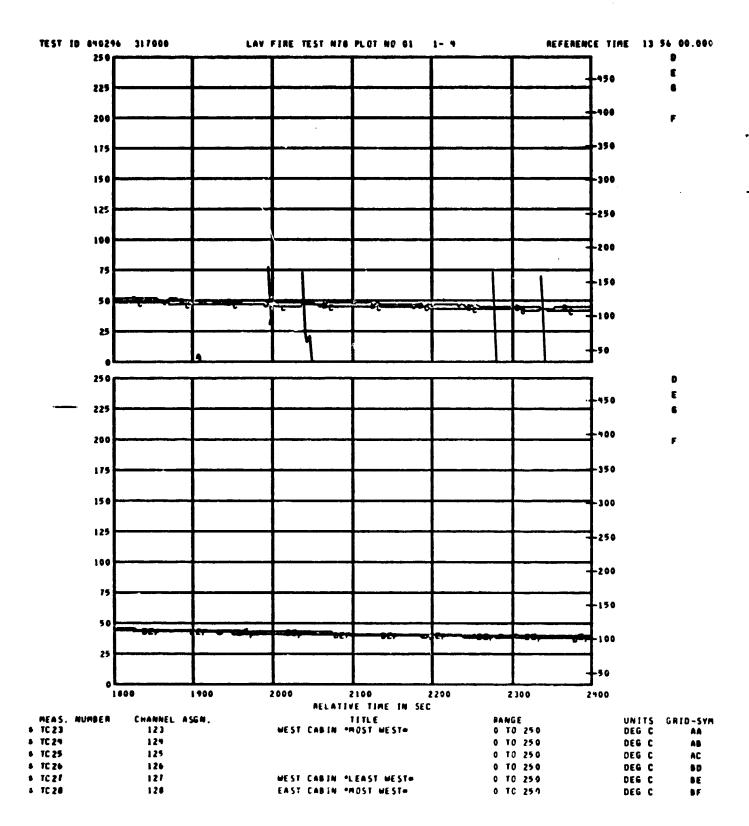


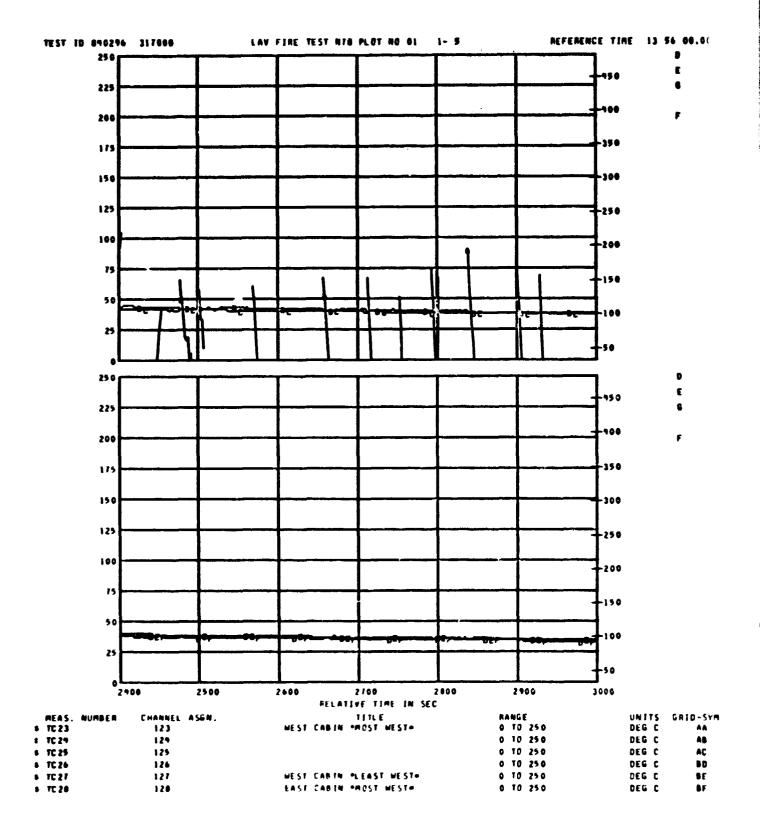


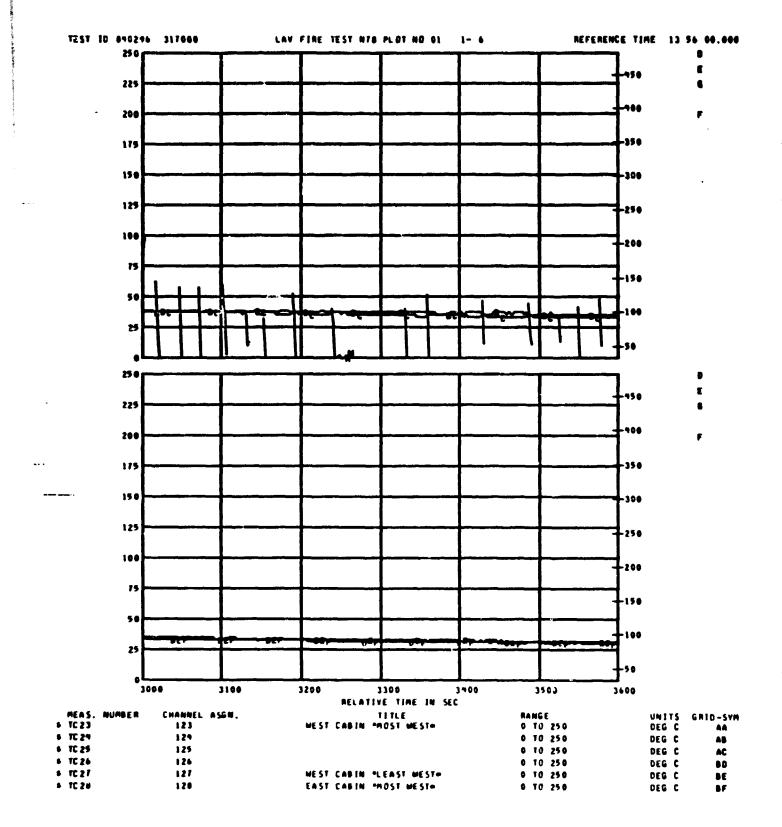


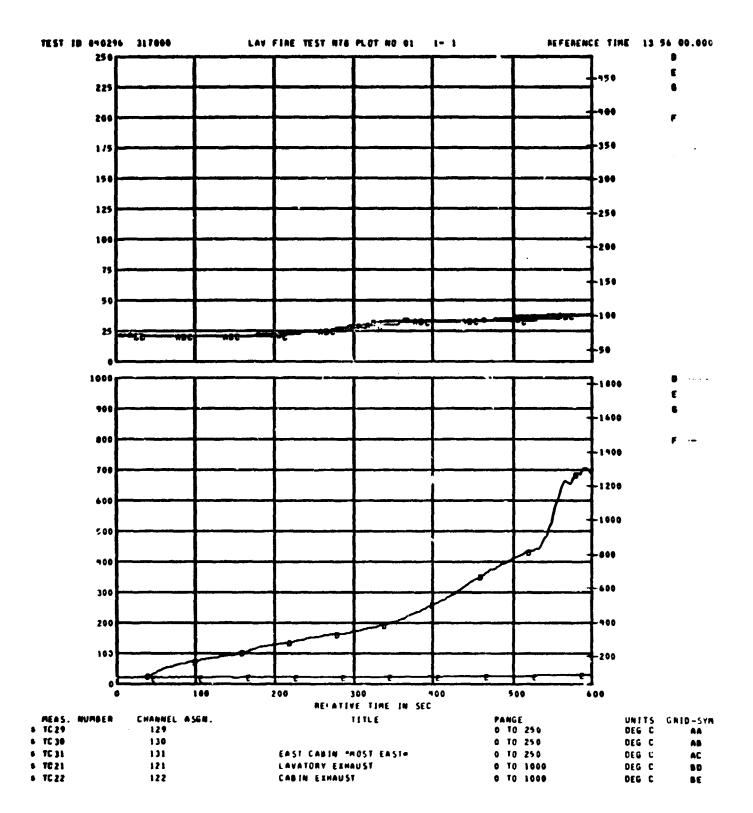


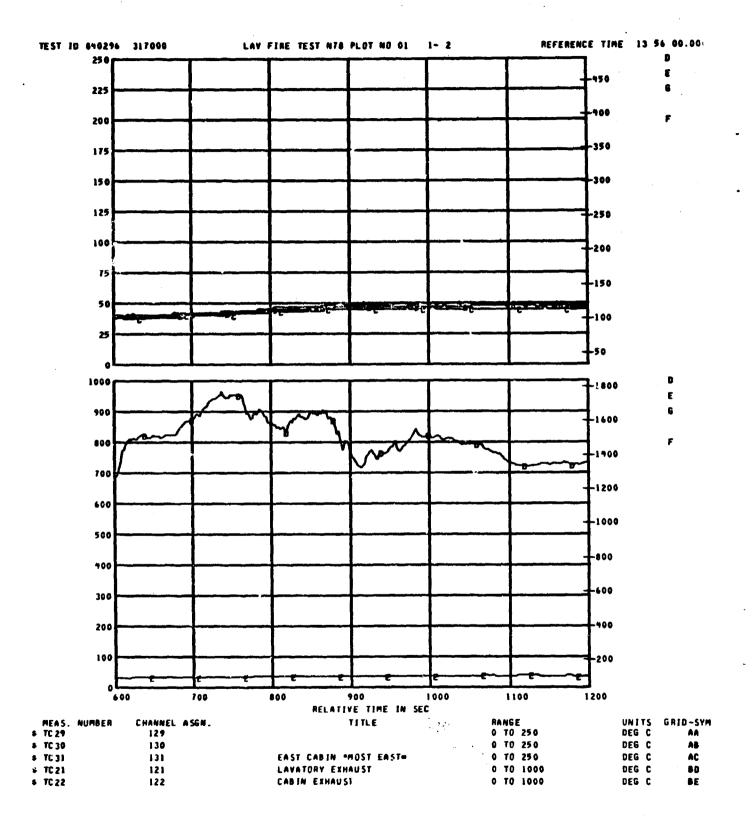


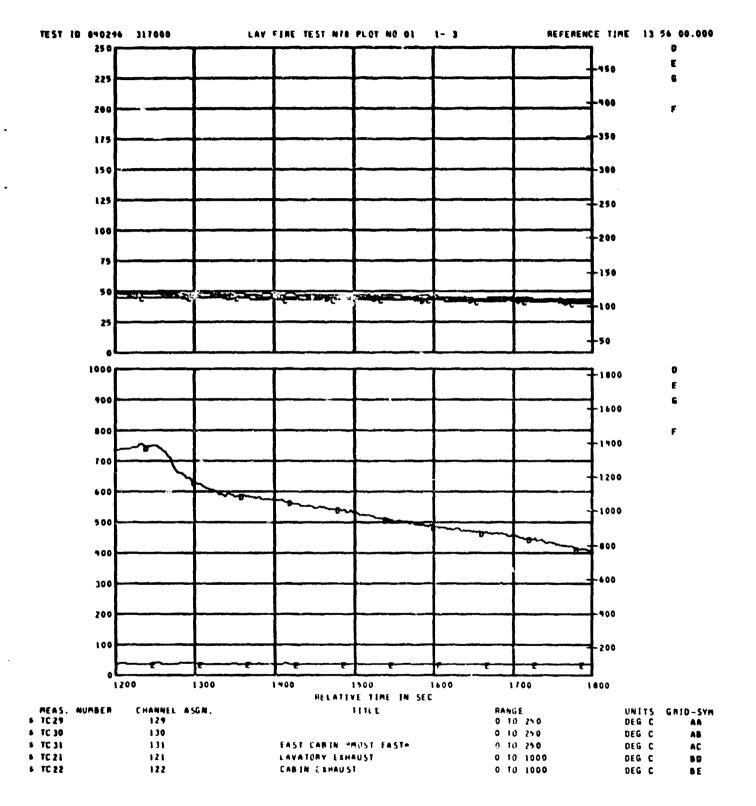


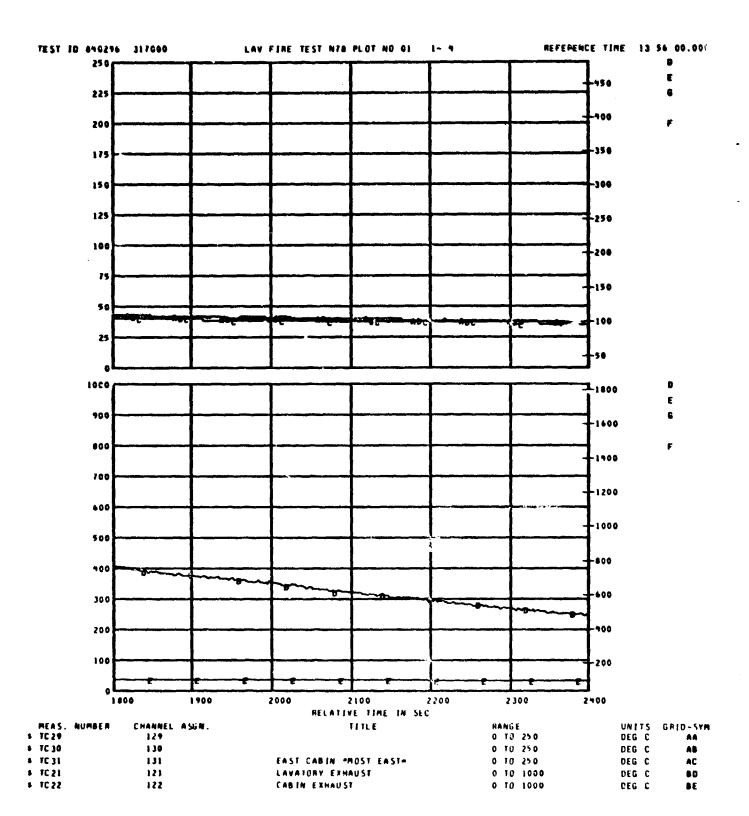


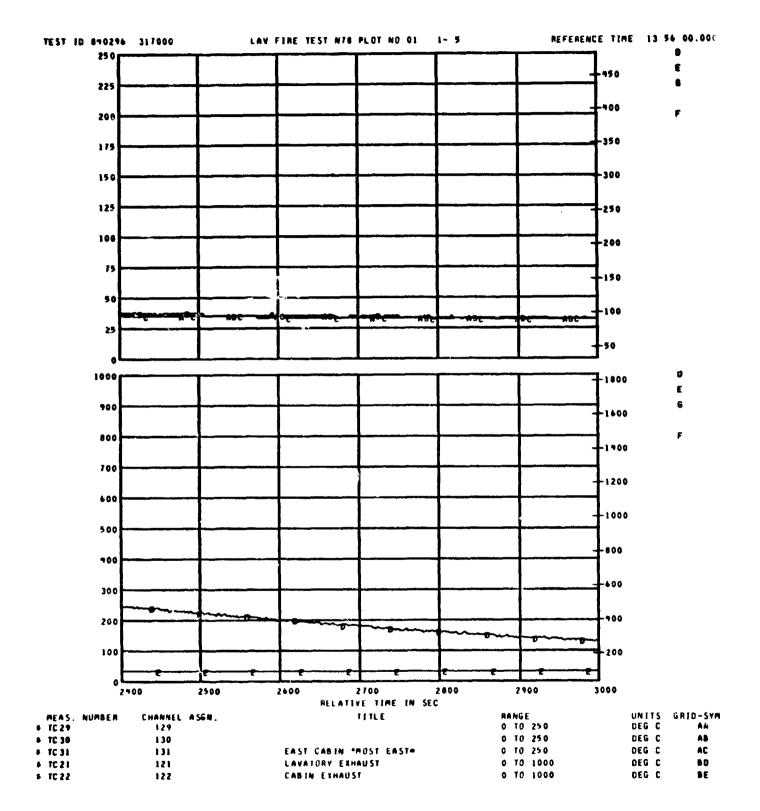


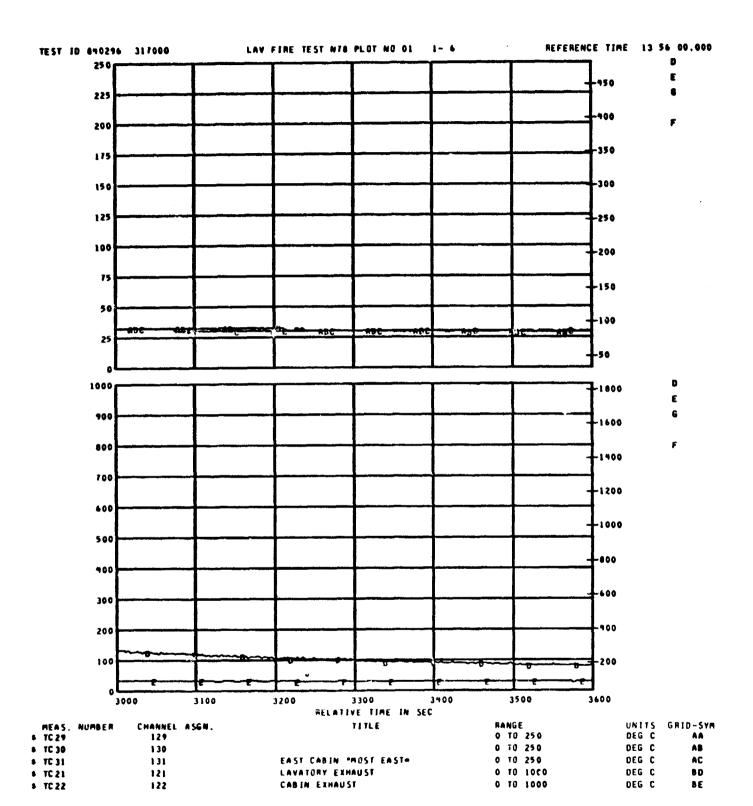


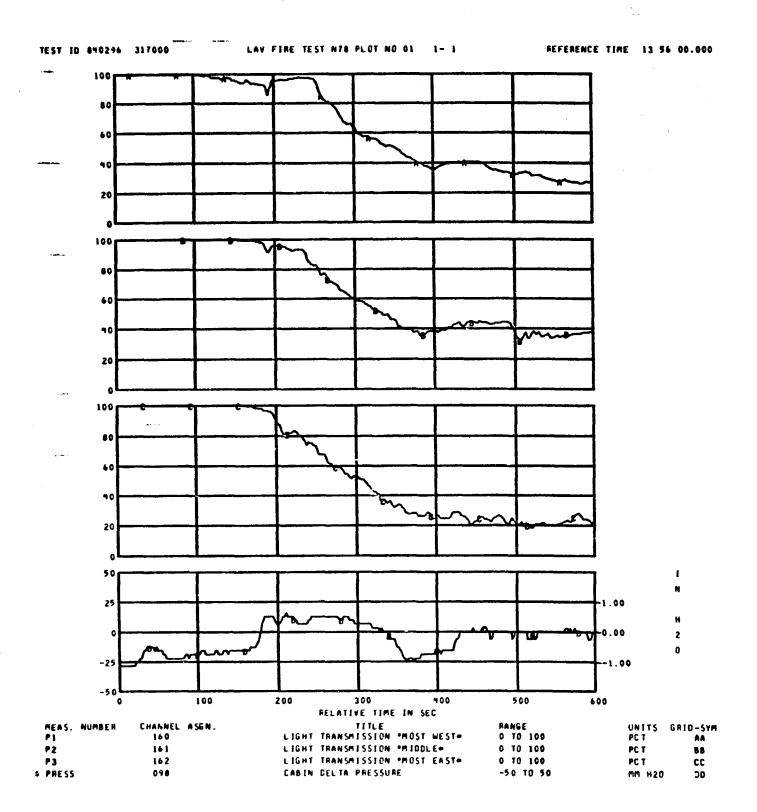


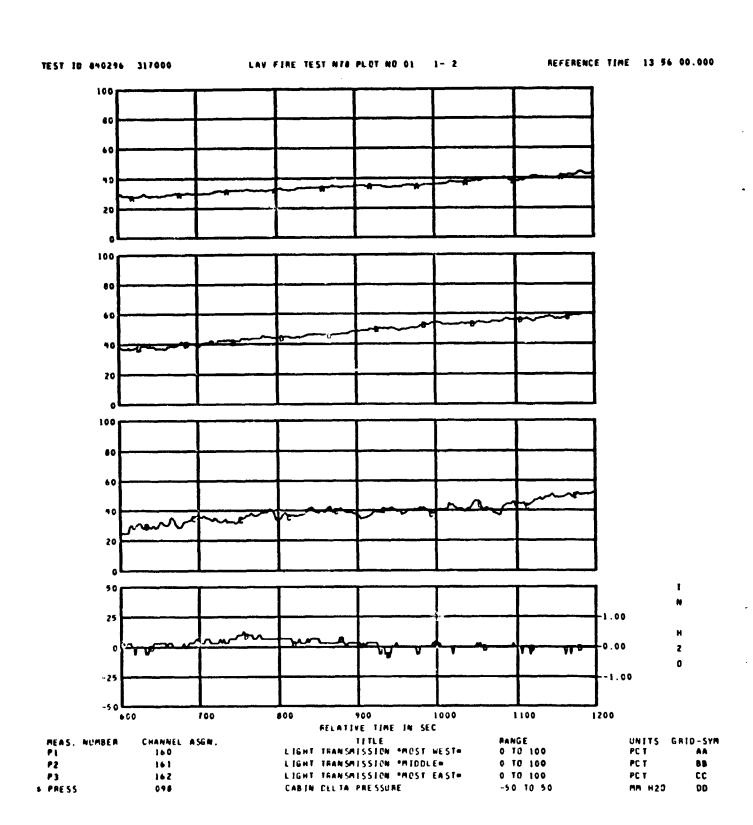


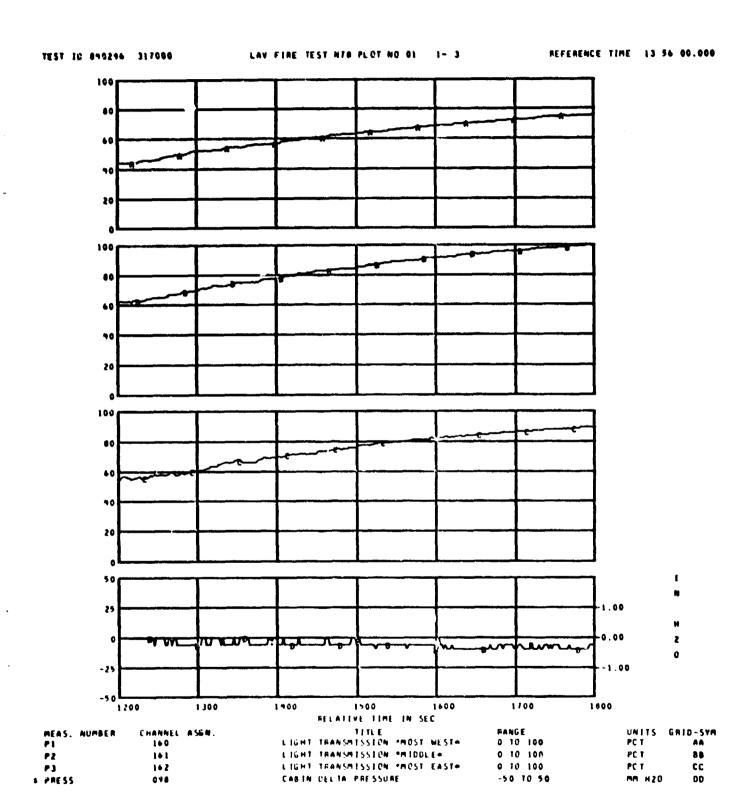


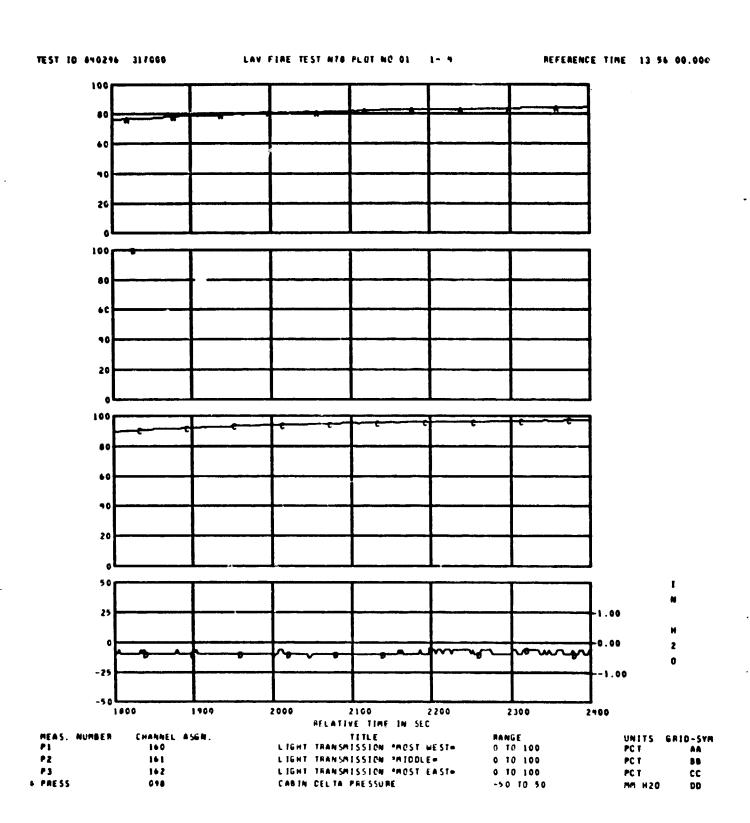


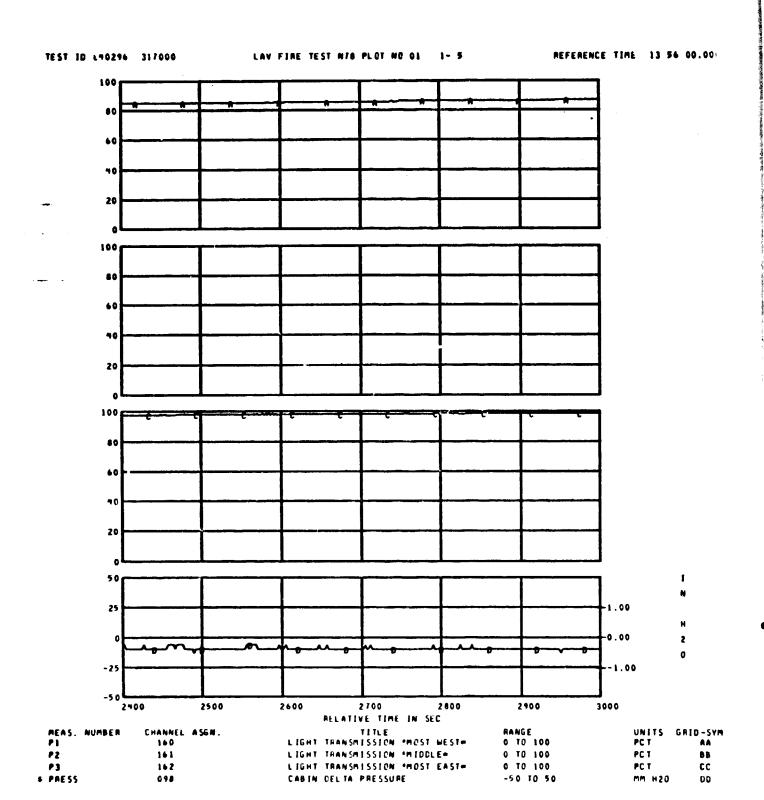


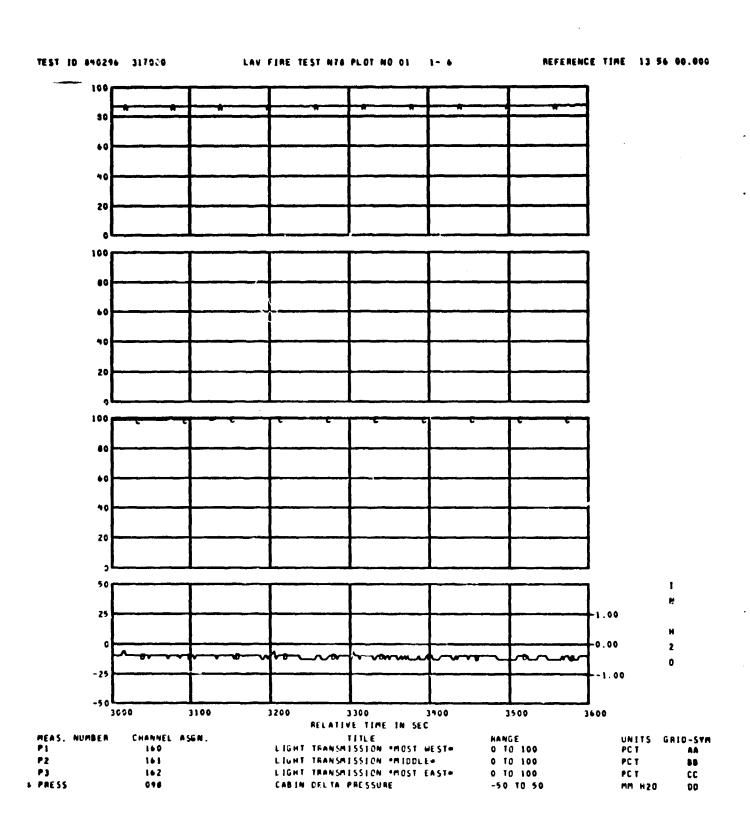




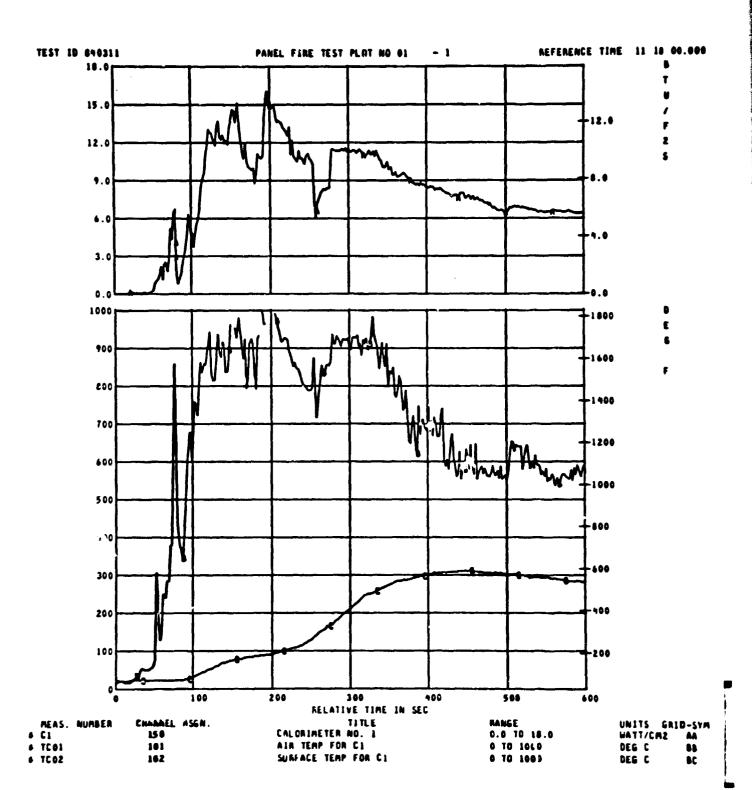


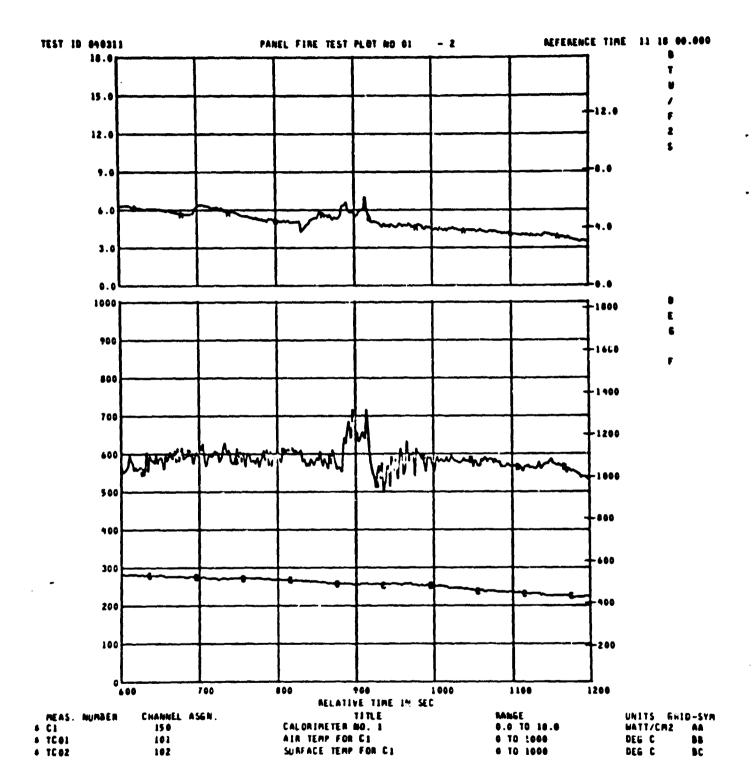


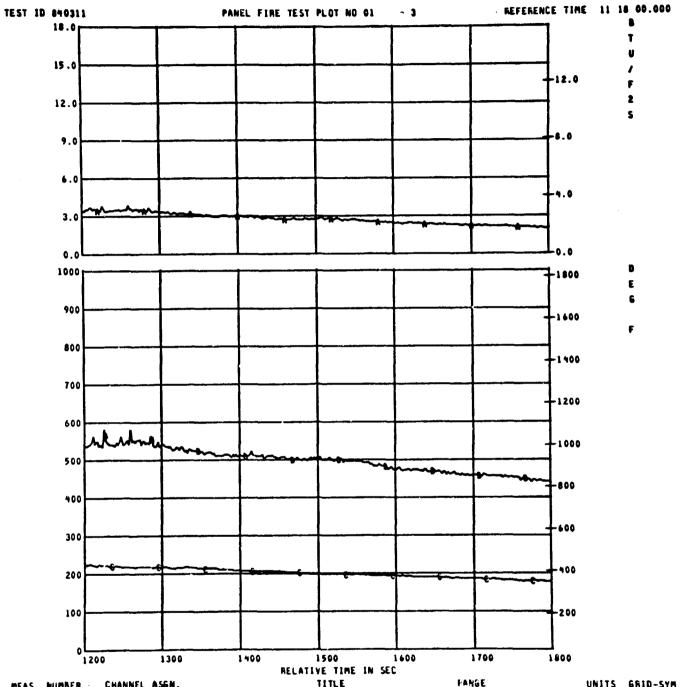




## MODULE B TEST DATA



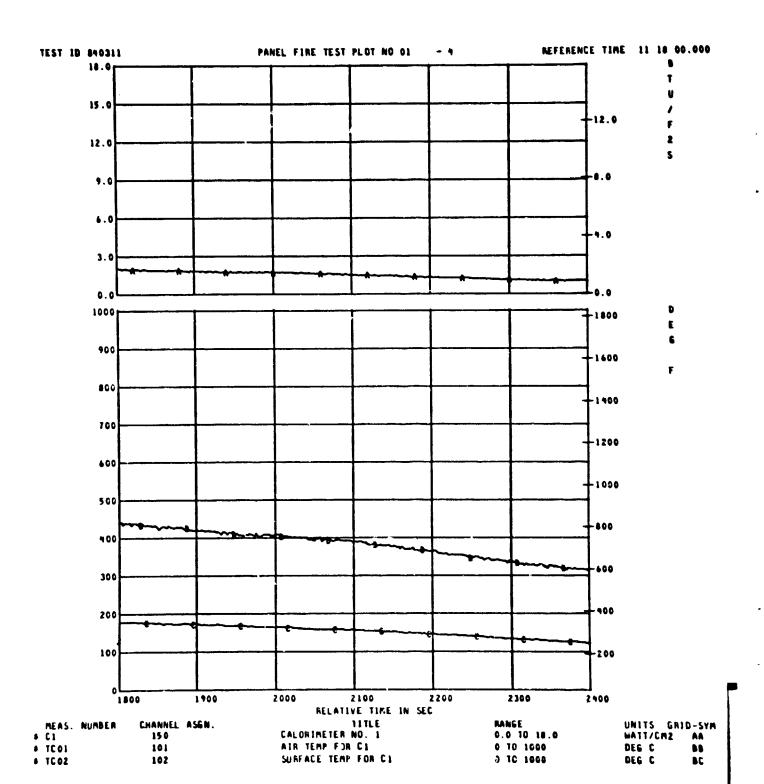


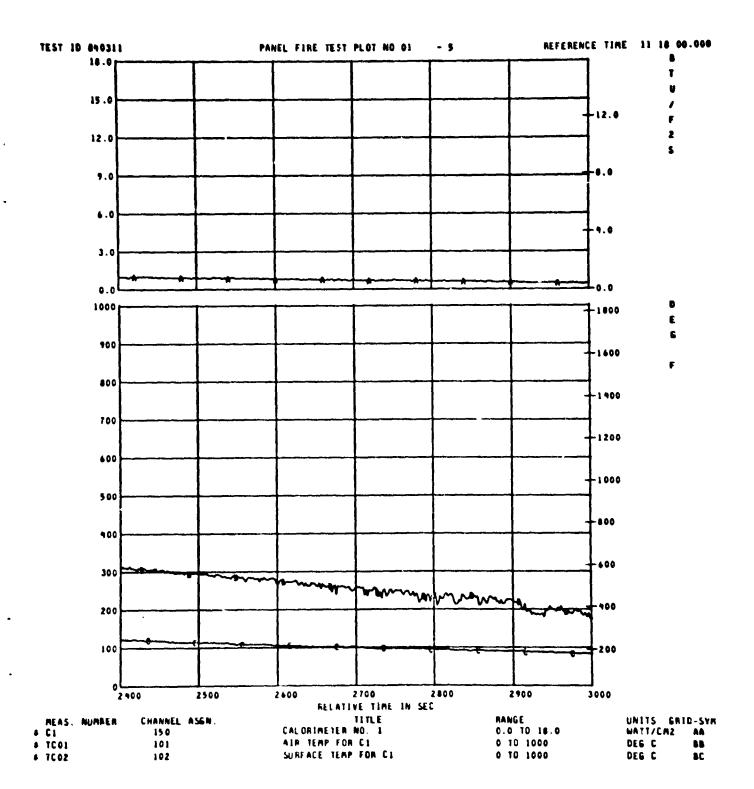


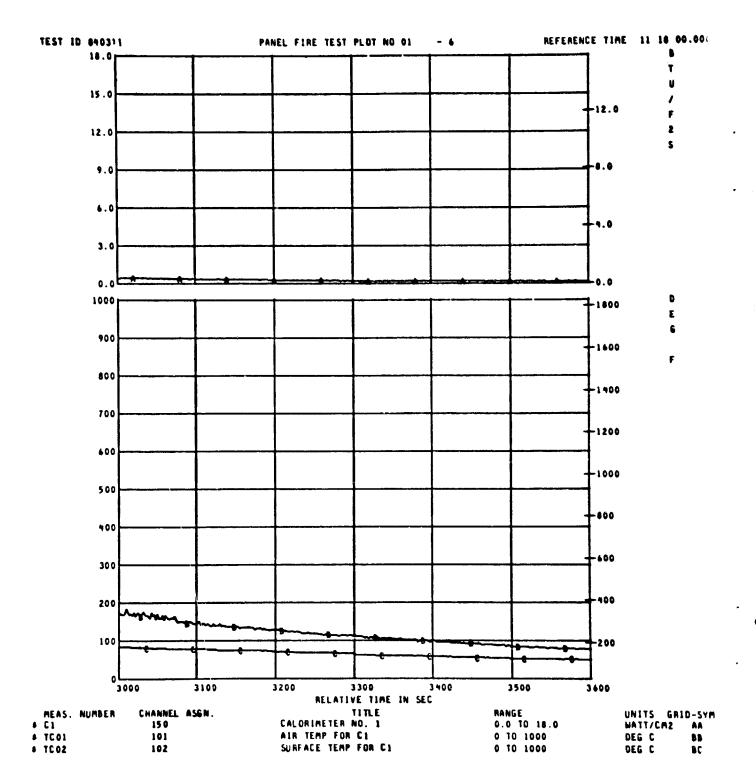
FANGE 0.0 TO 18.0 0 TO 1000 TITLE CALORIMETER NO. 1 UNITS GRID-SYM MEAS. NUMBER CHANNEL ASEN. • C1 150 101 AIR TEMP FOR C1 DEG C 11 # TCO1 SURFACE TEMP FOR C1 0 TO 1000 DEG C # TCO2 102 BC

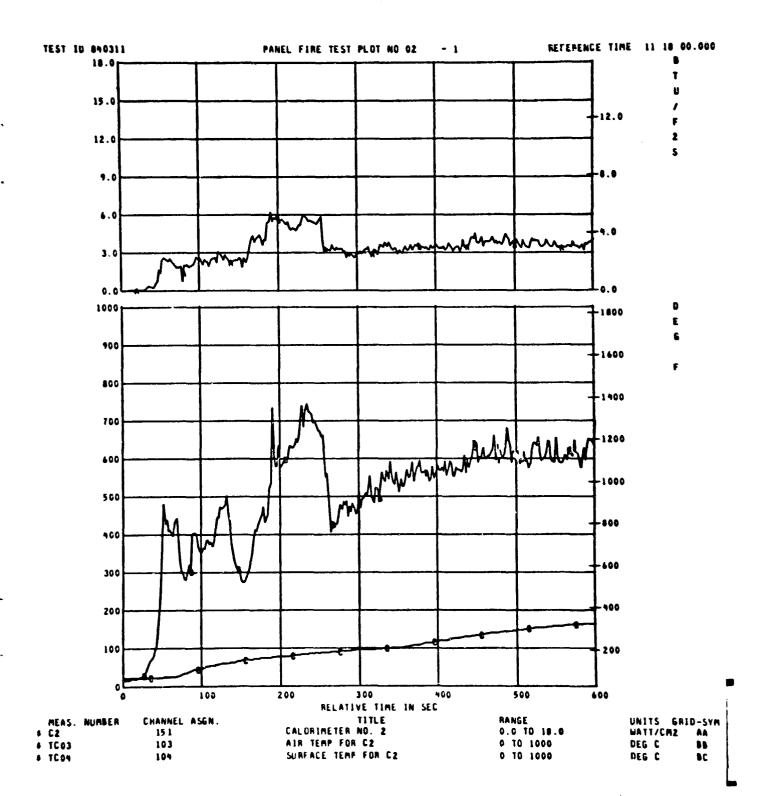
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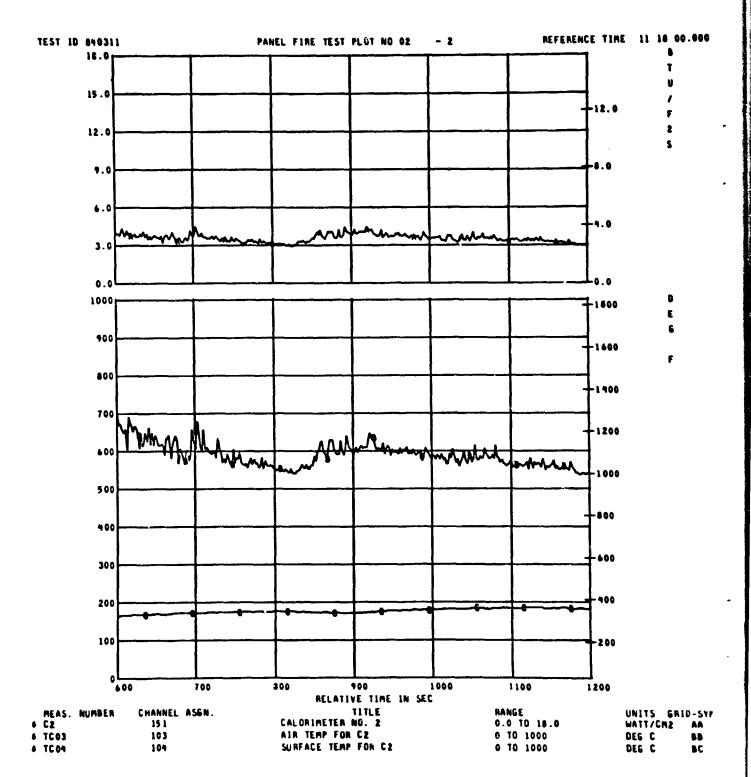
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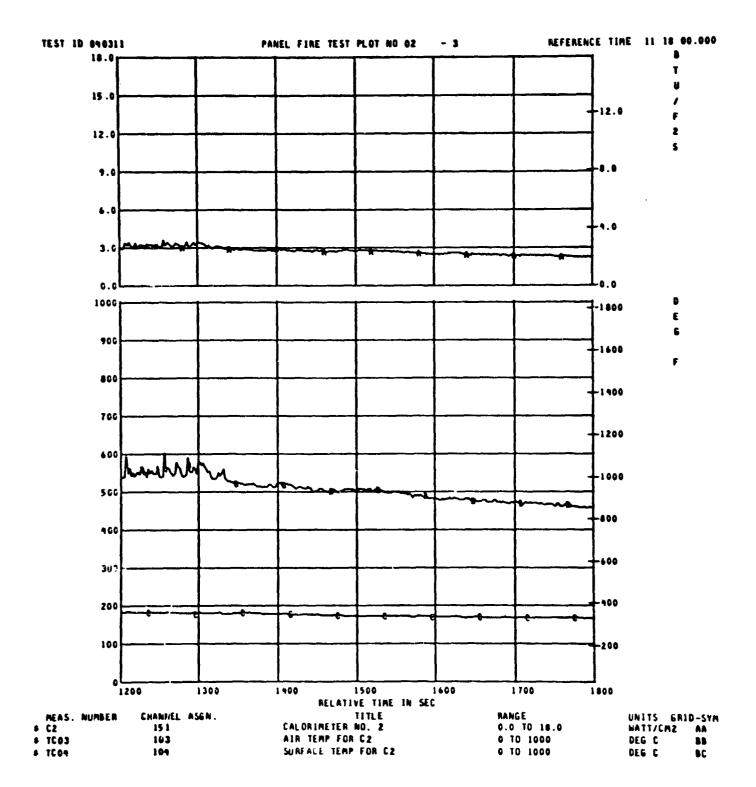


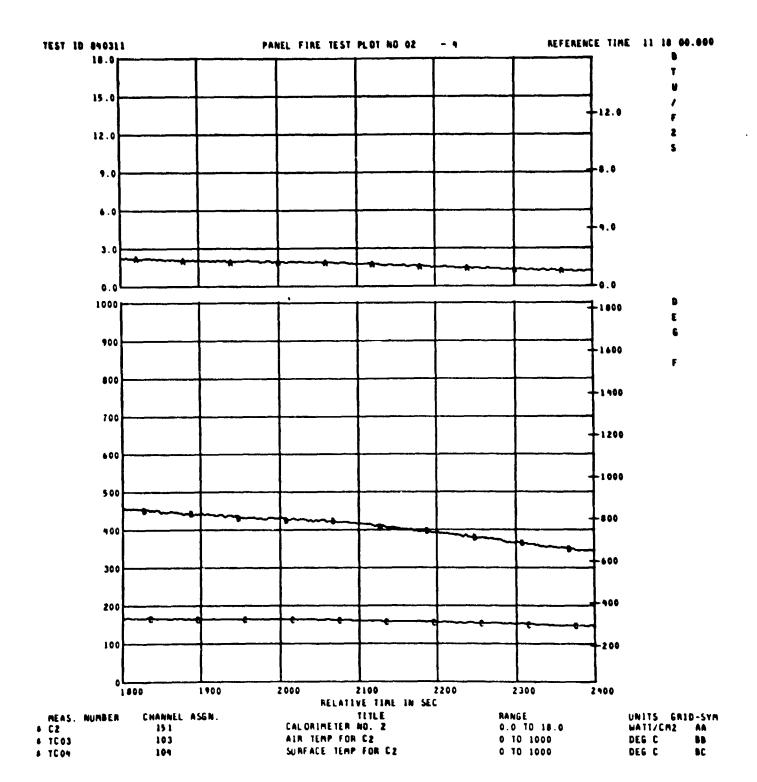


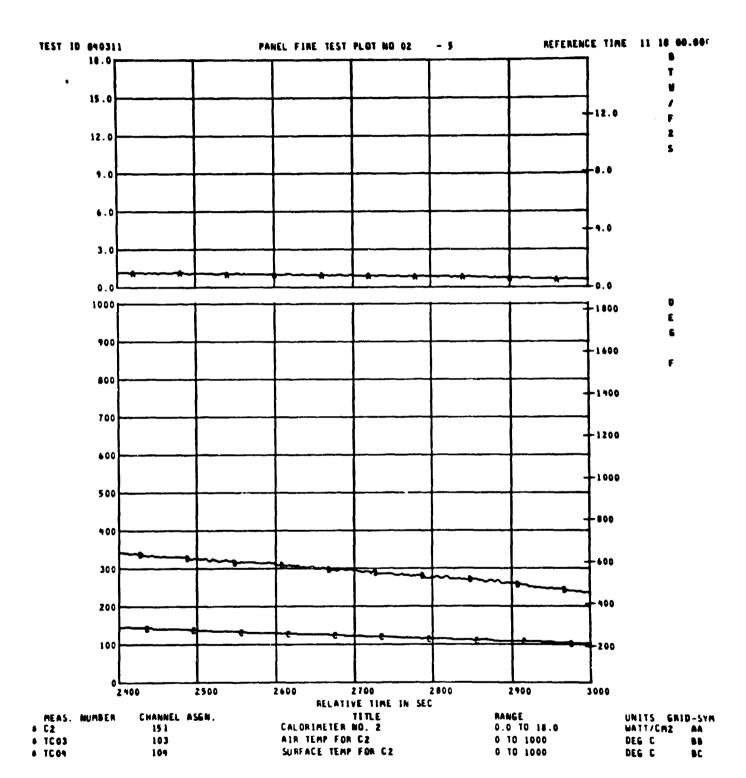




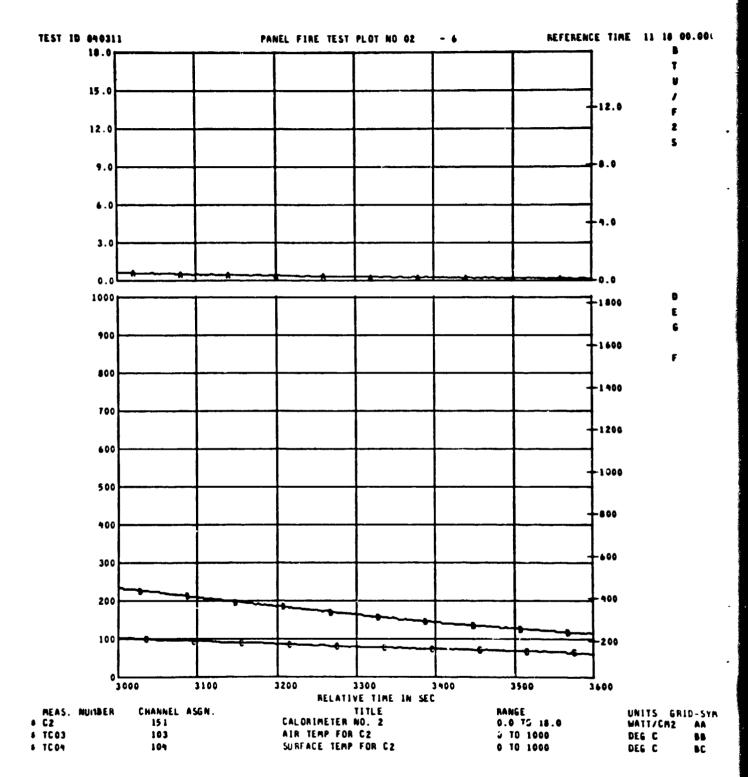


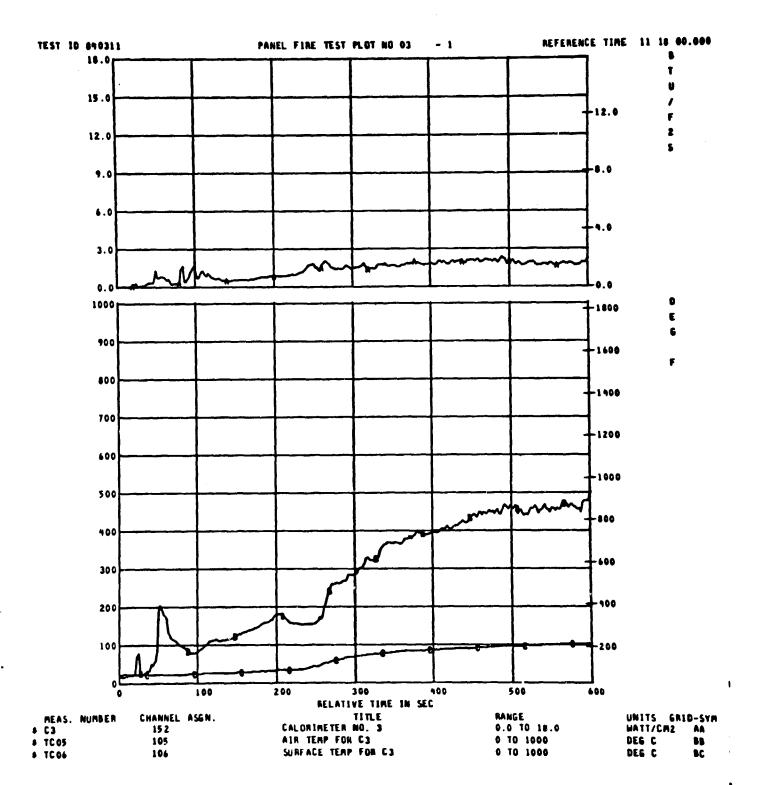


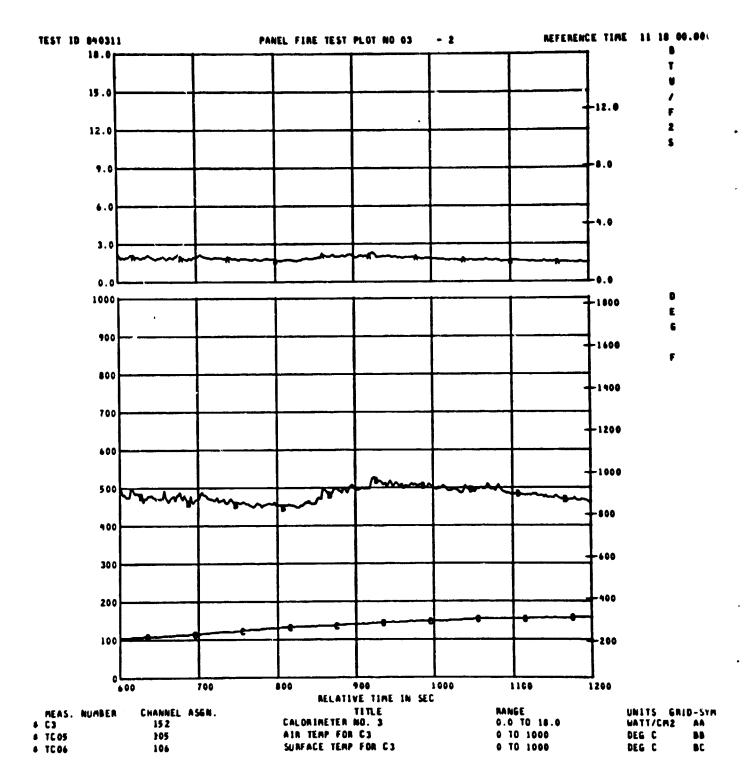


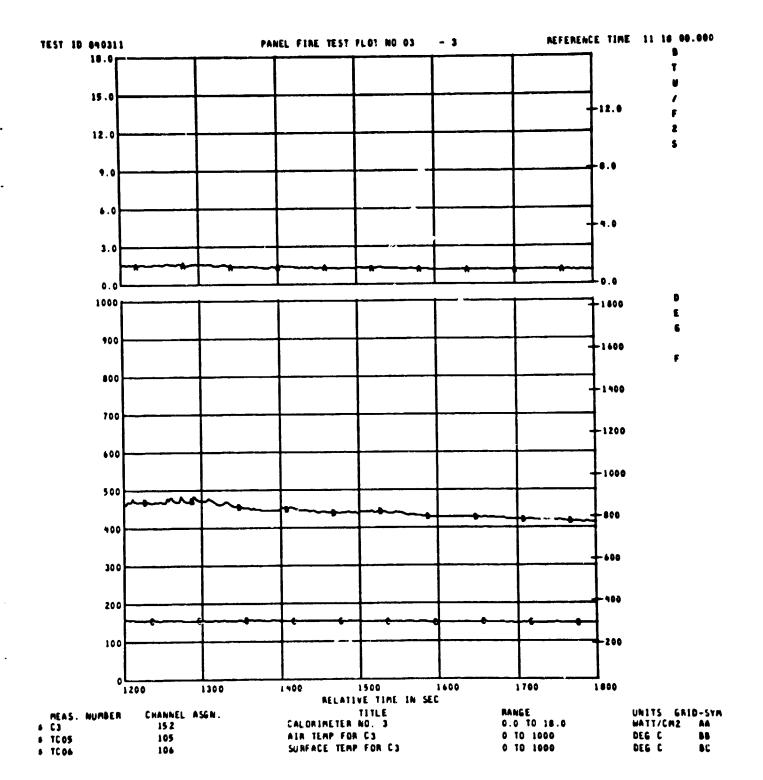


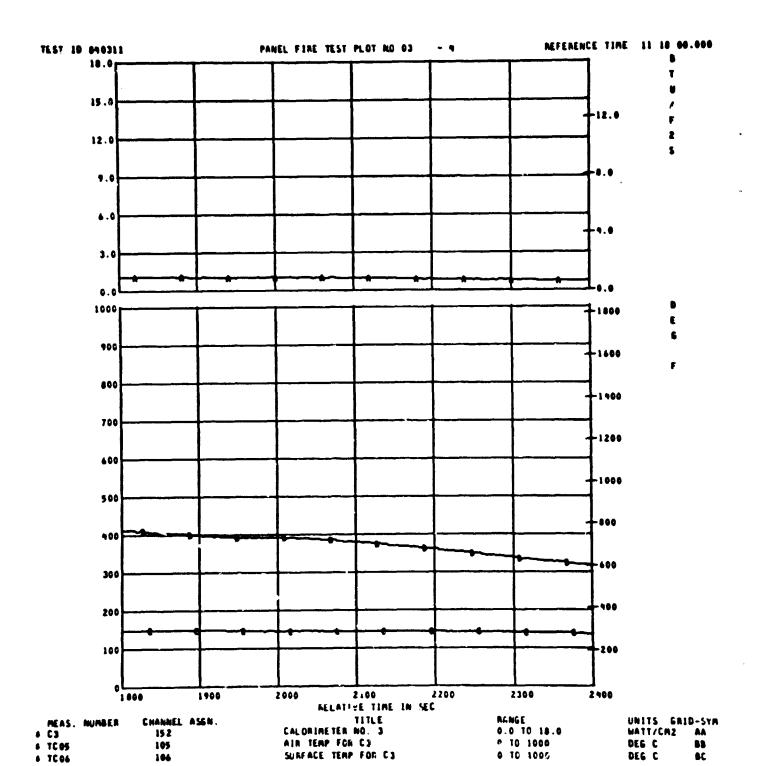
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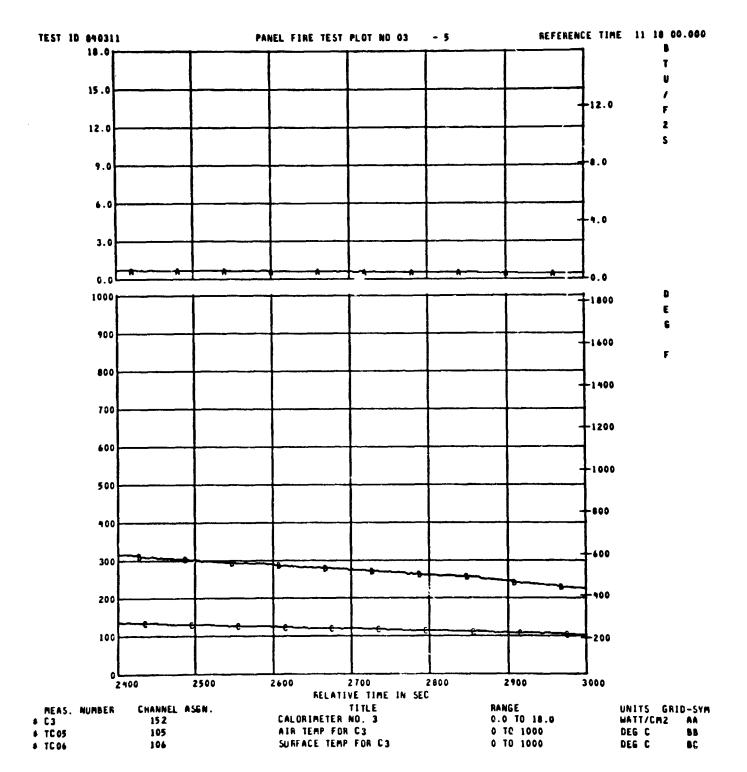


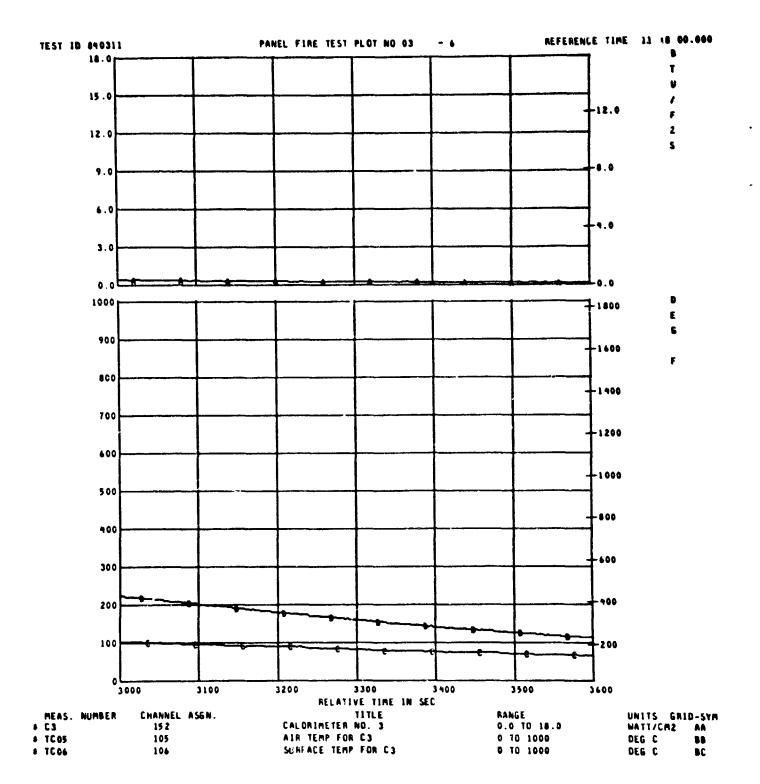


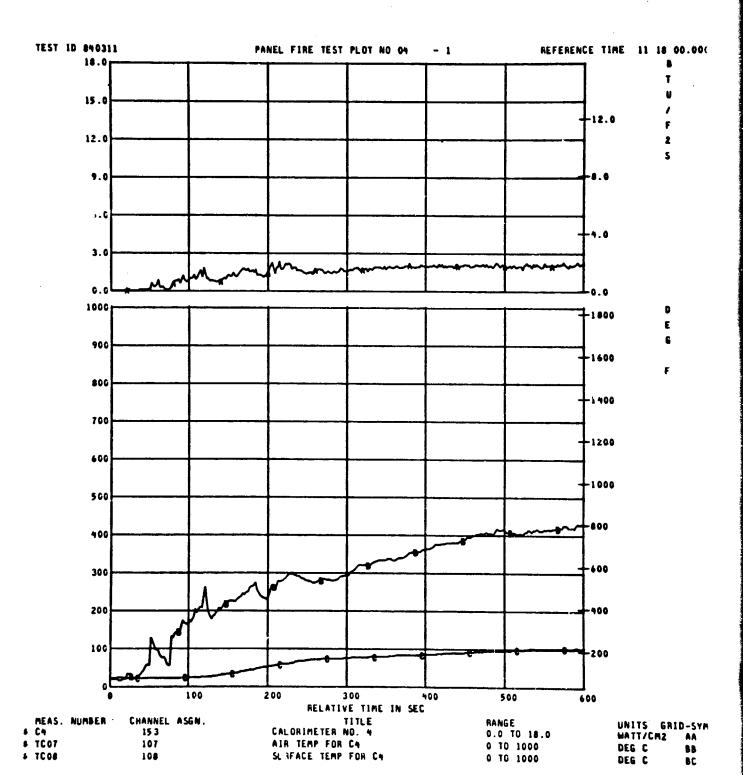




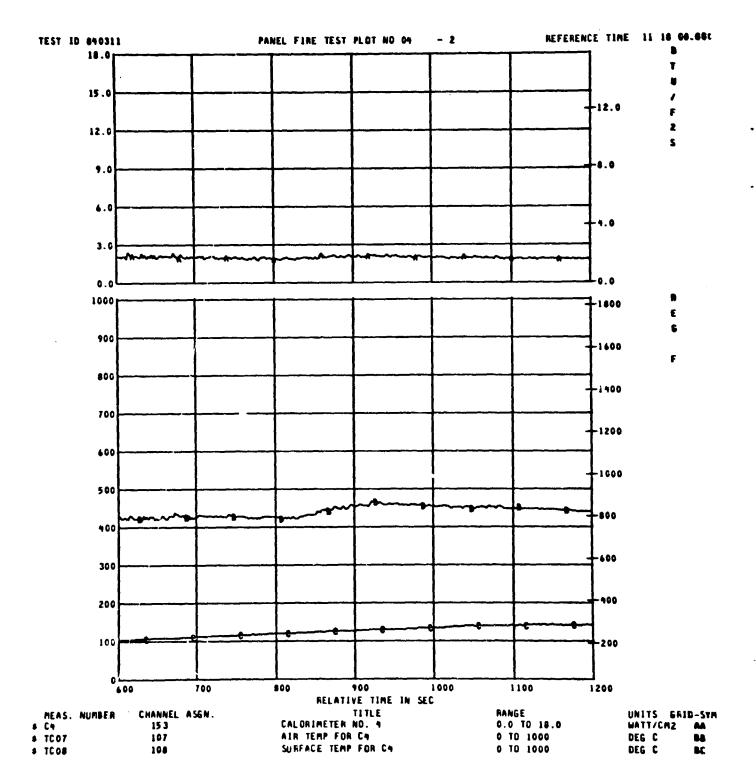


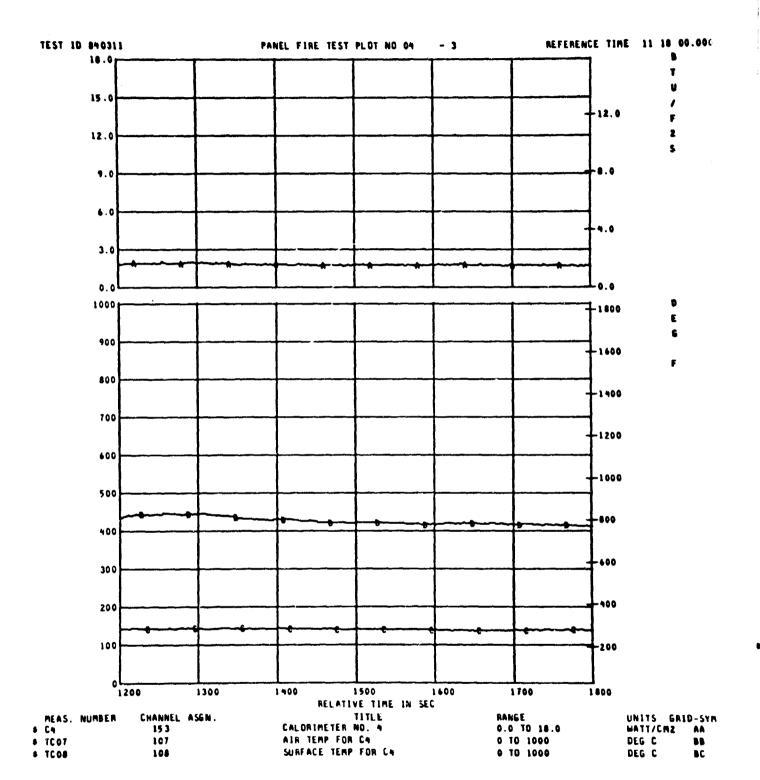


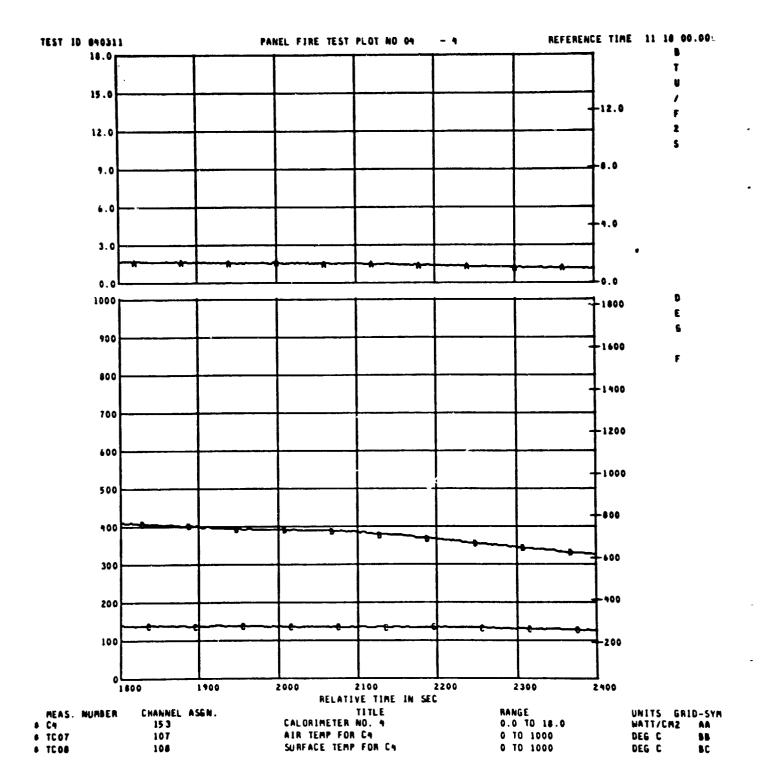


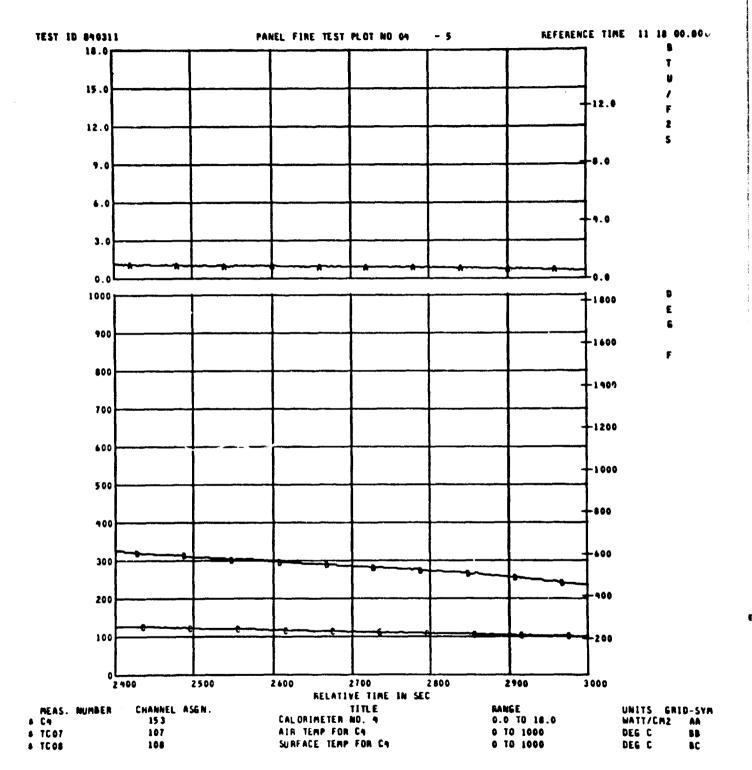


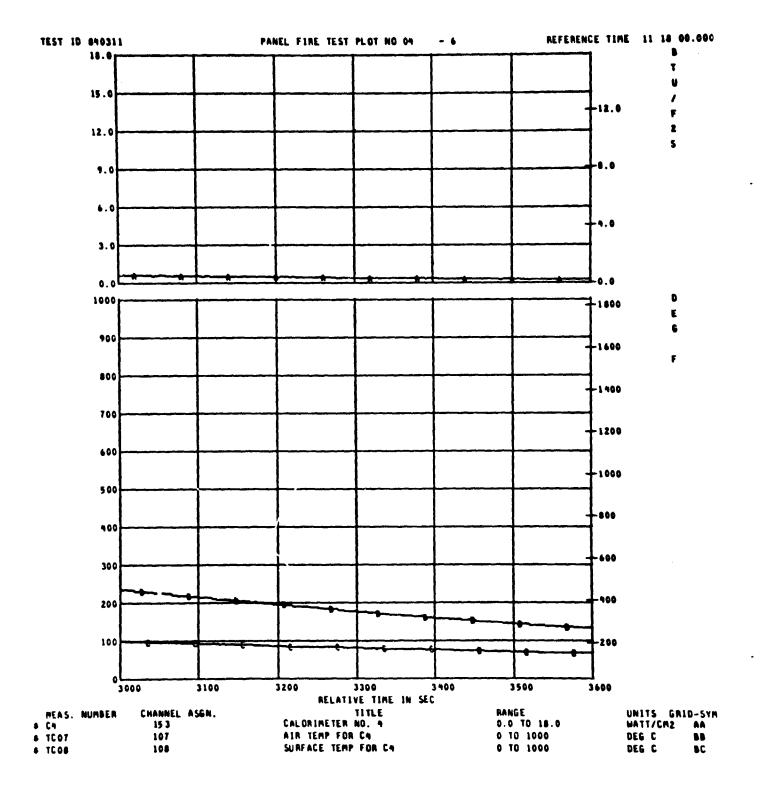
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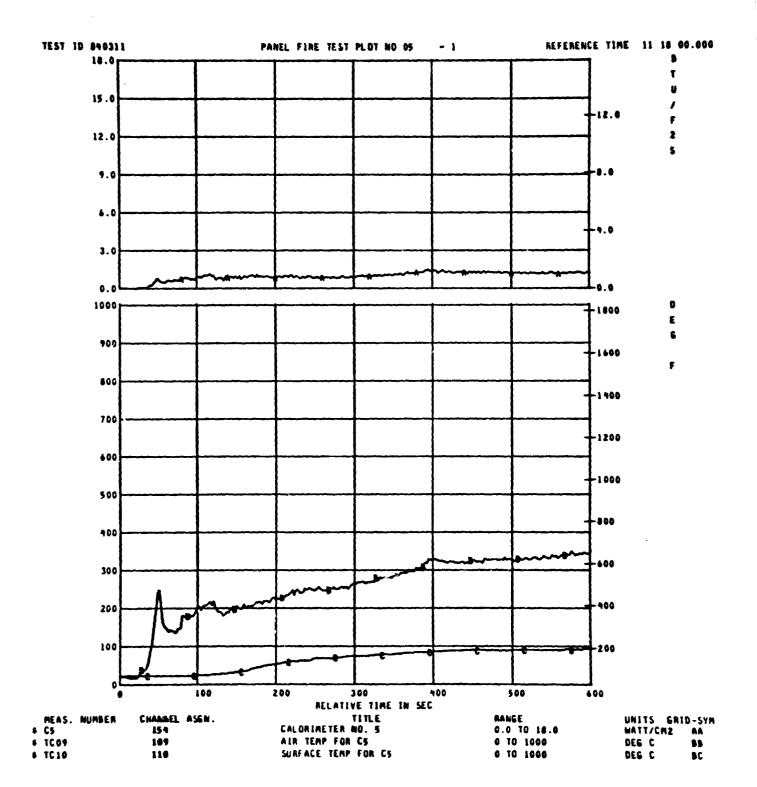


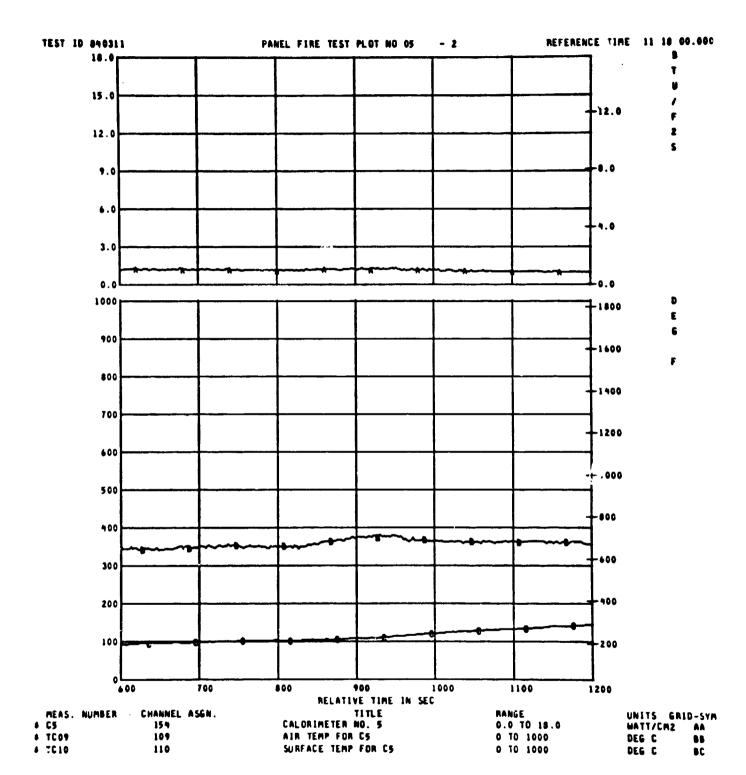


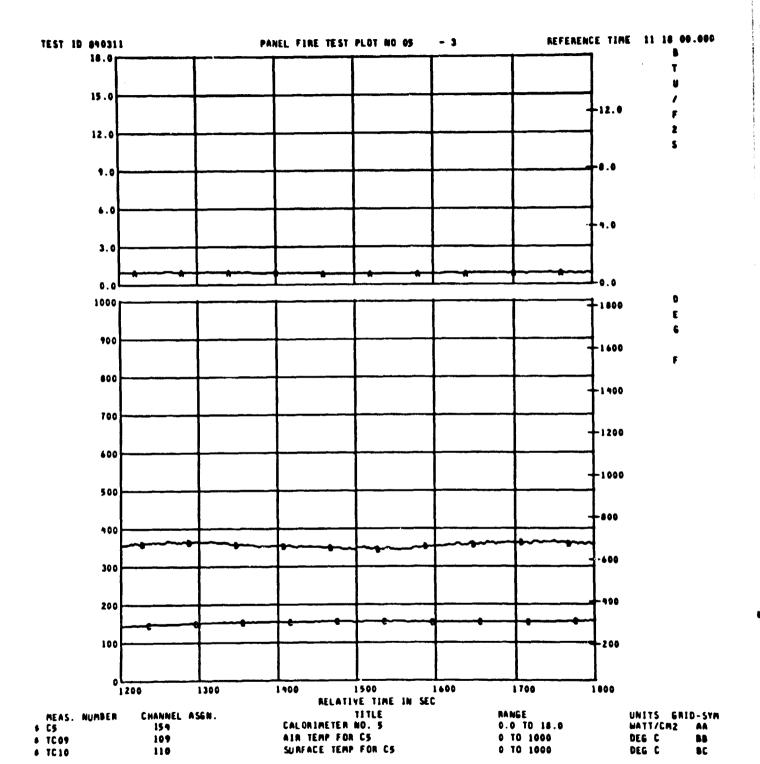


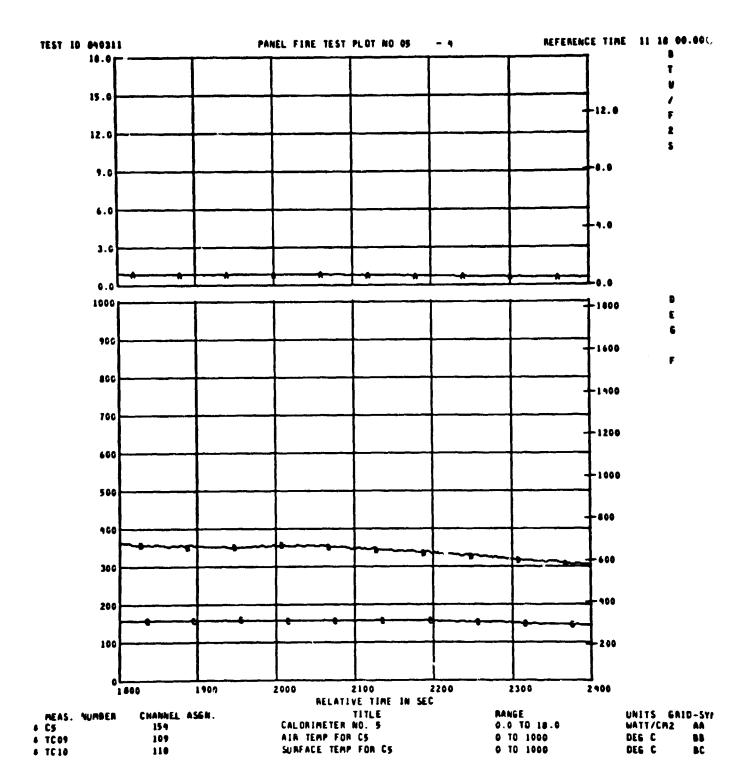


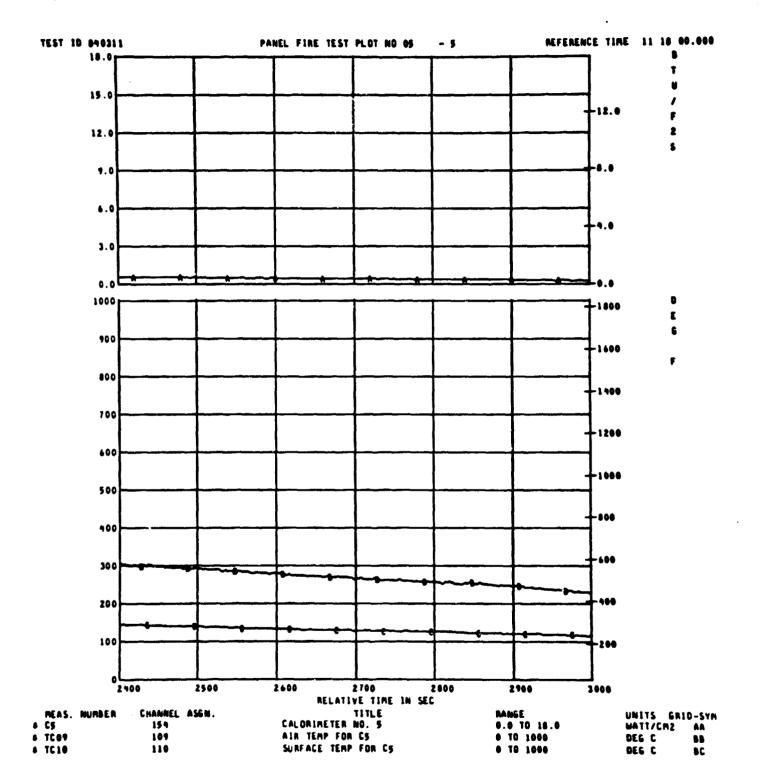


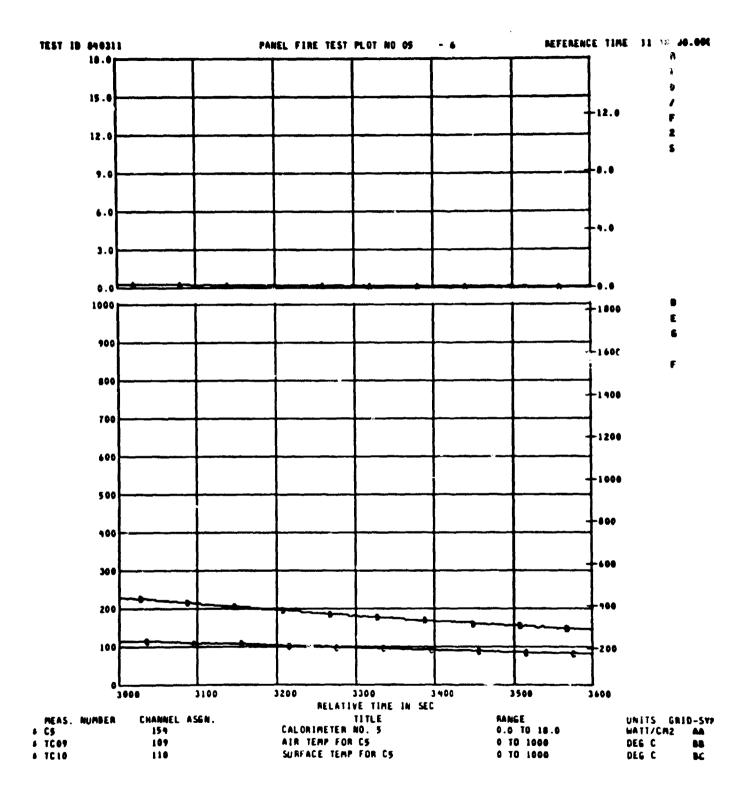


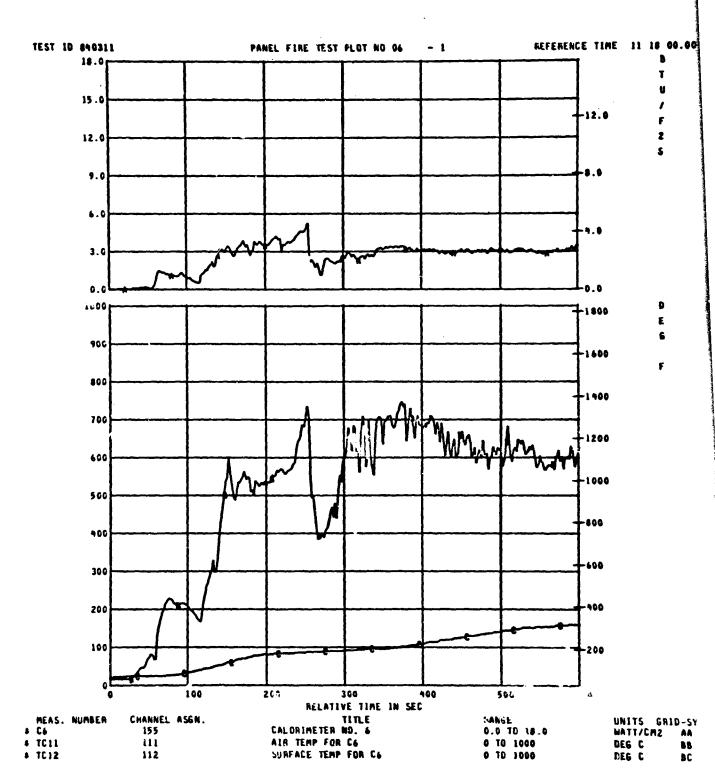


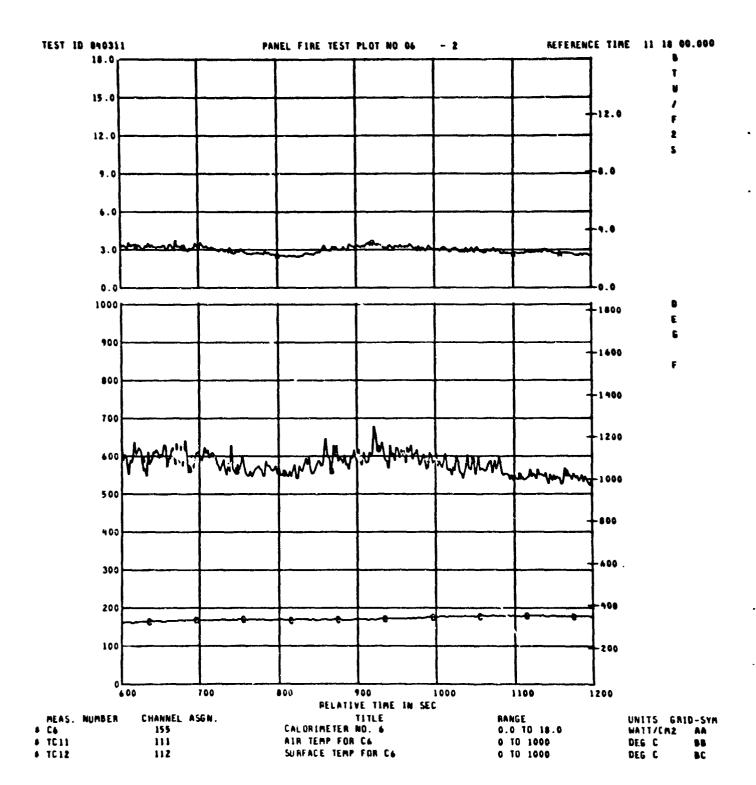


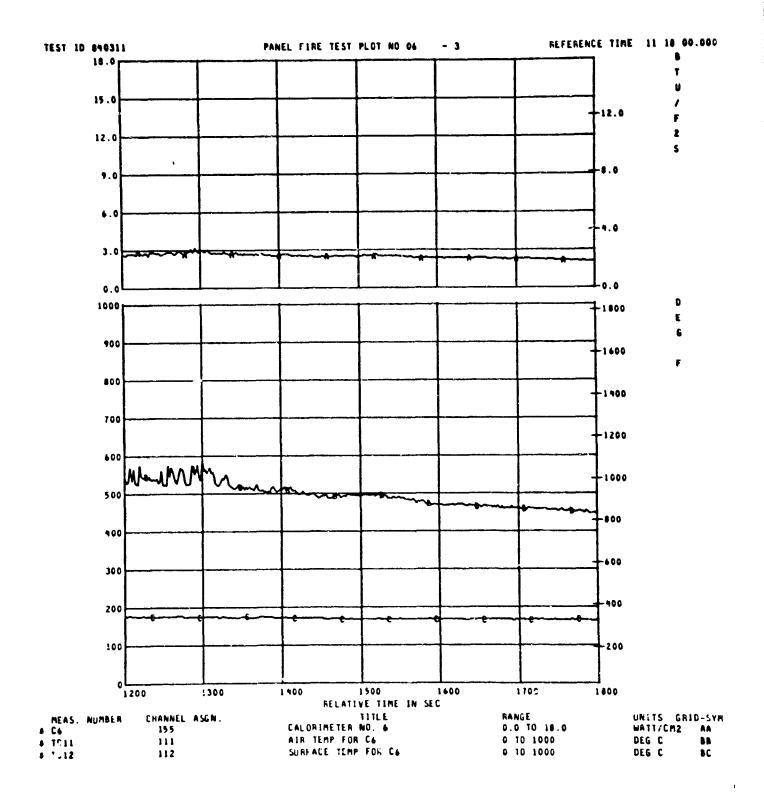




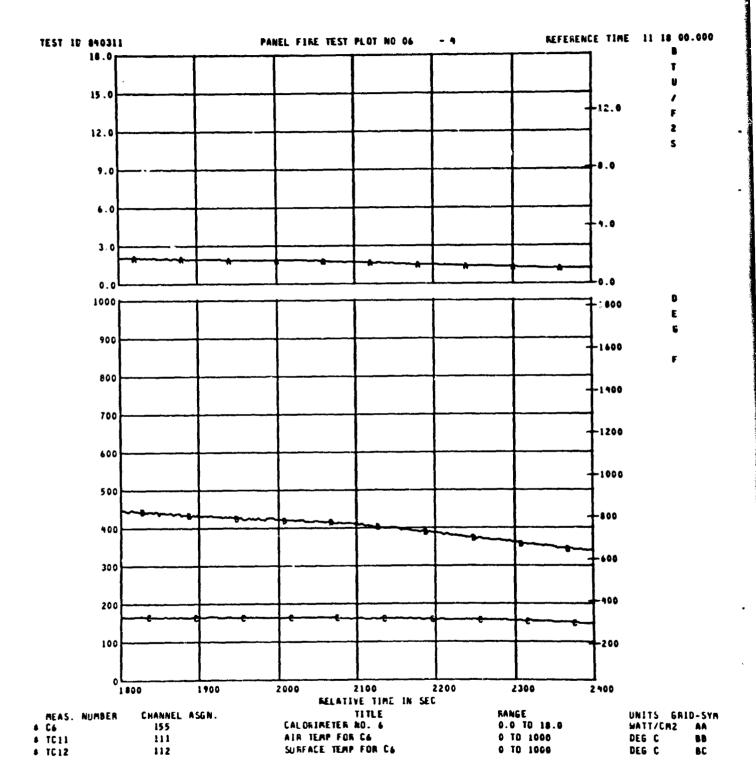


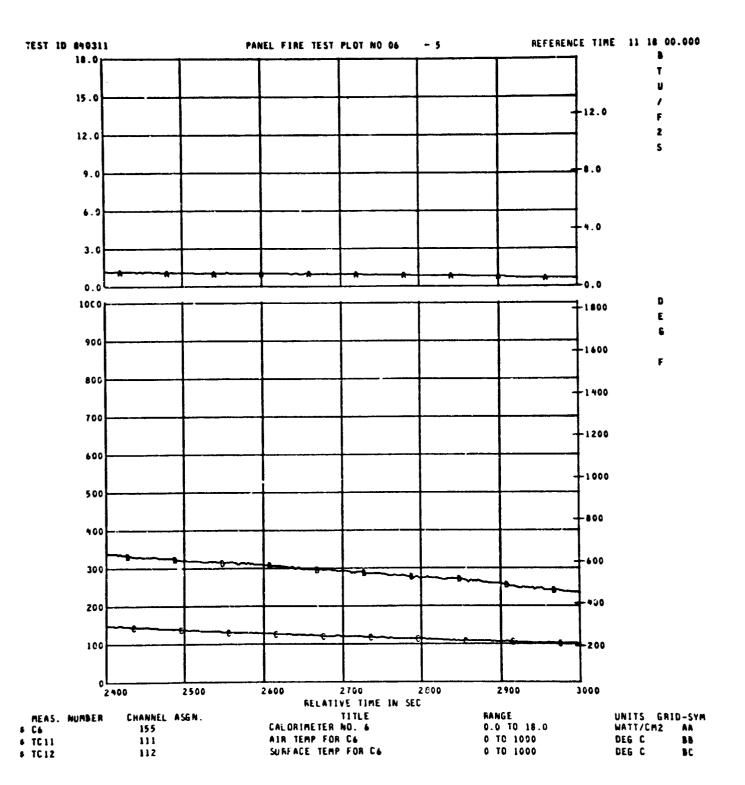


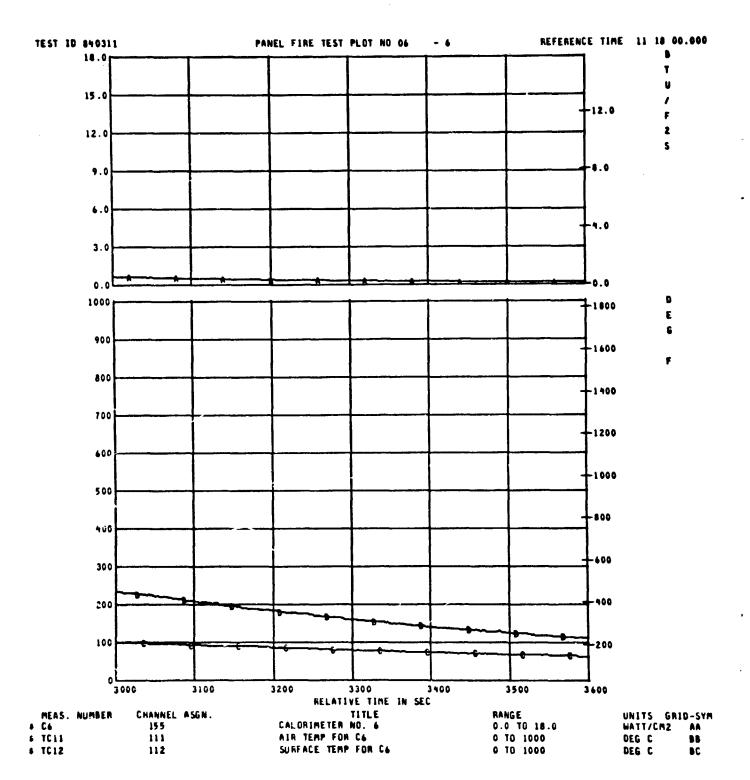


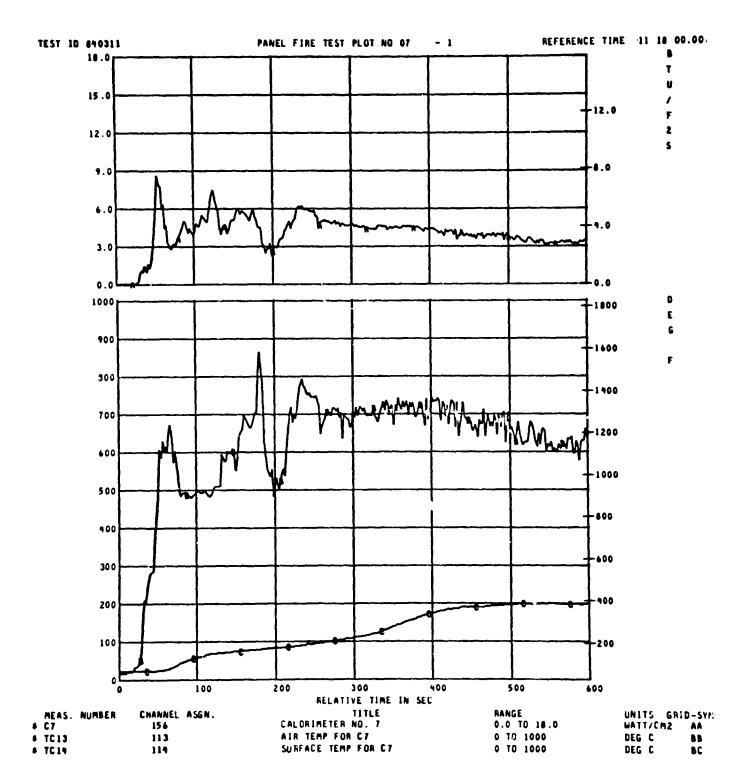


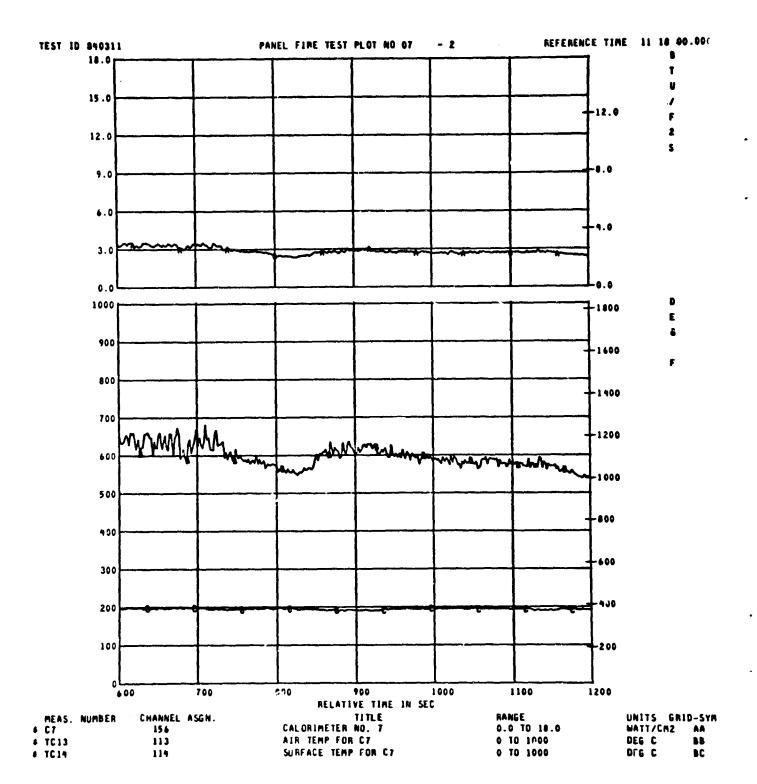
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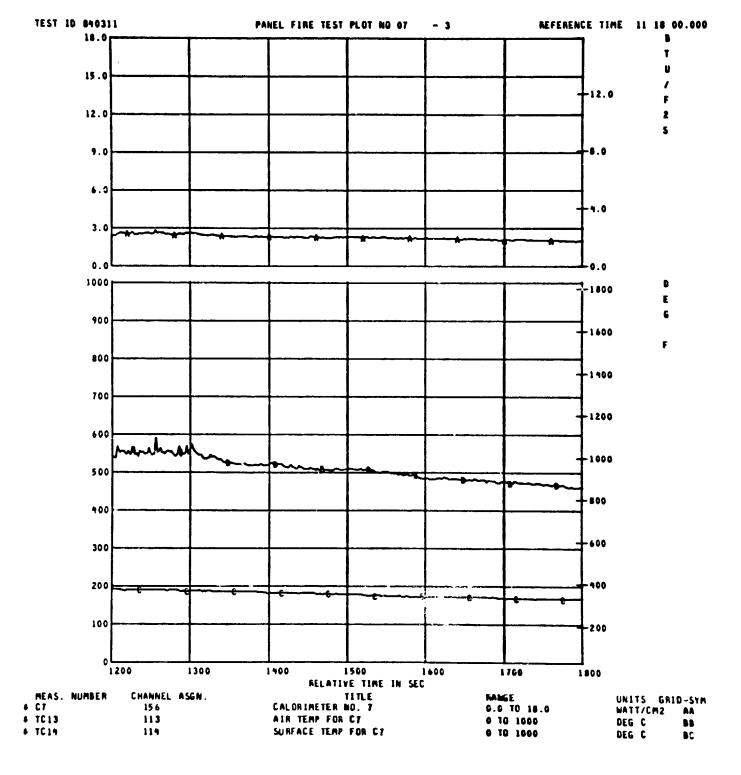




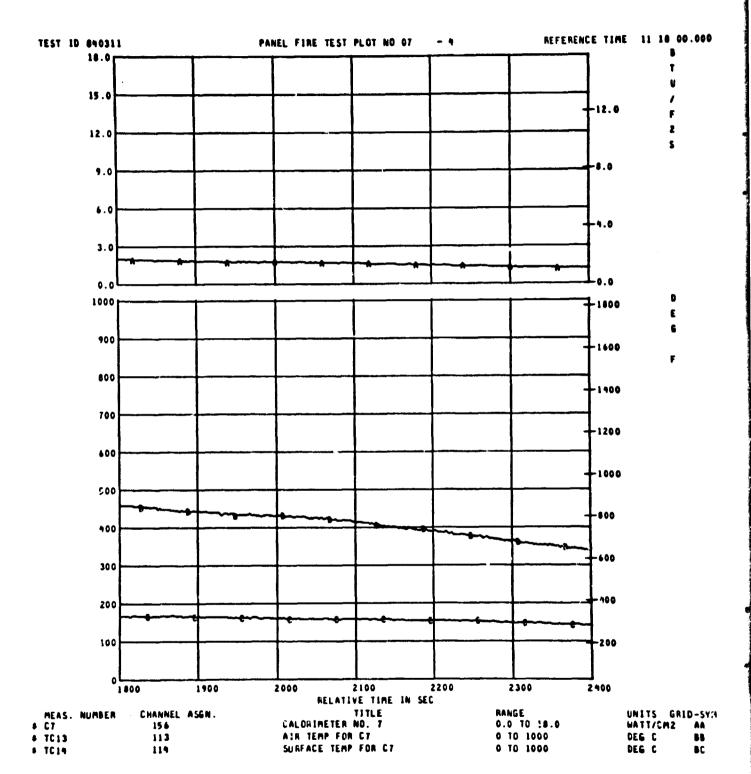


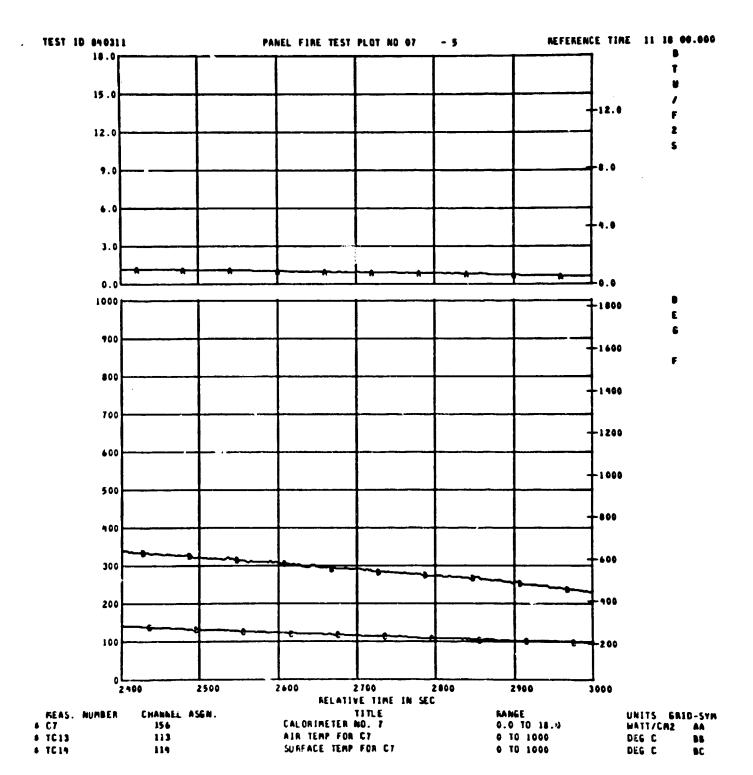


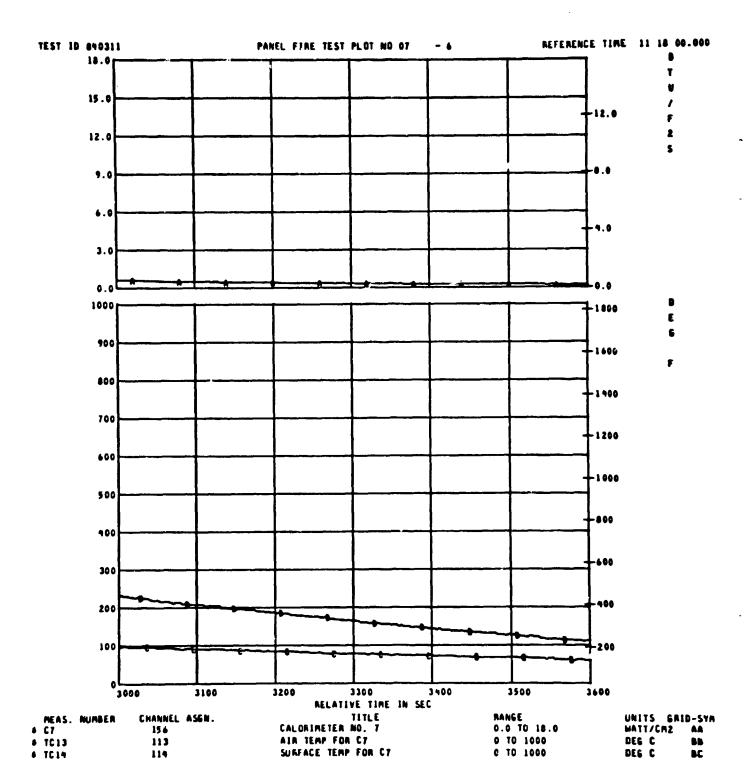


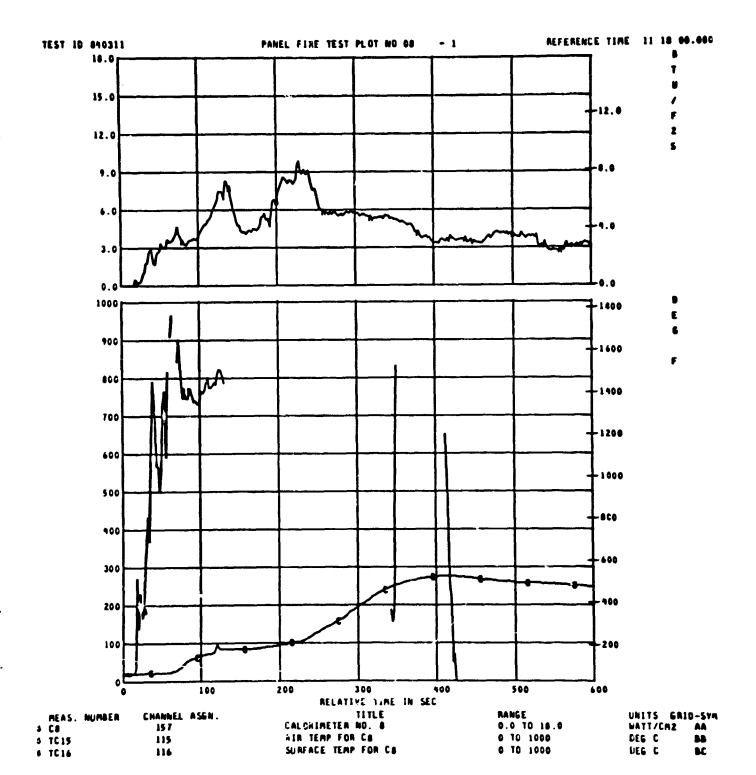


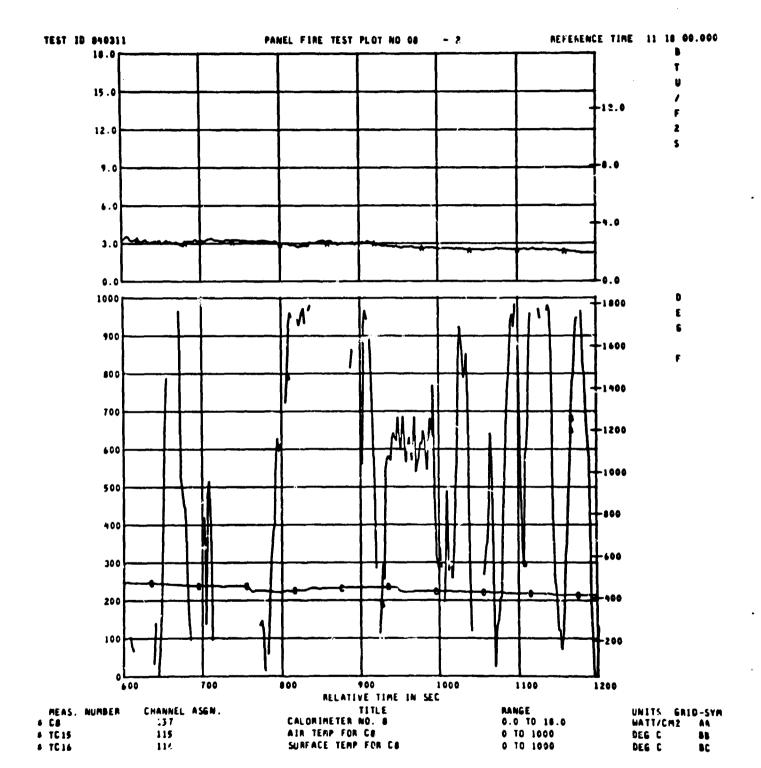
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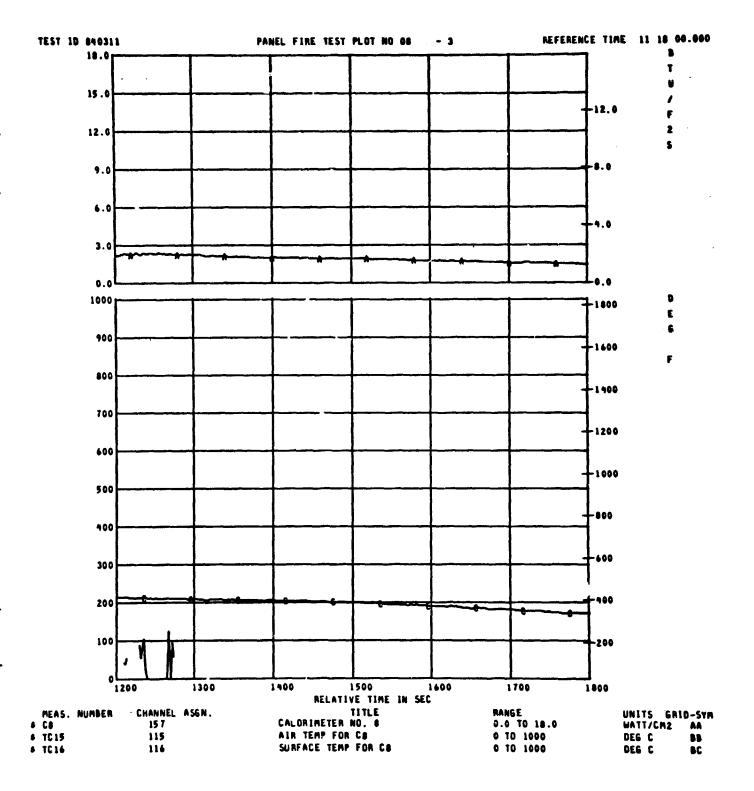




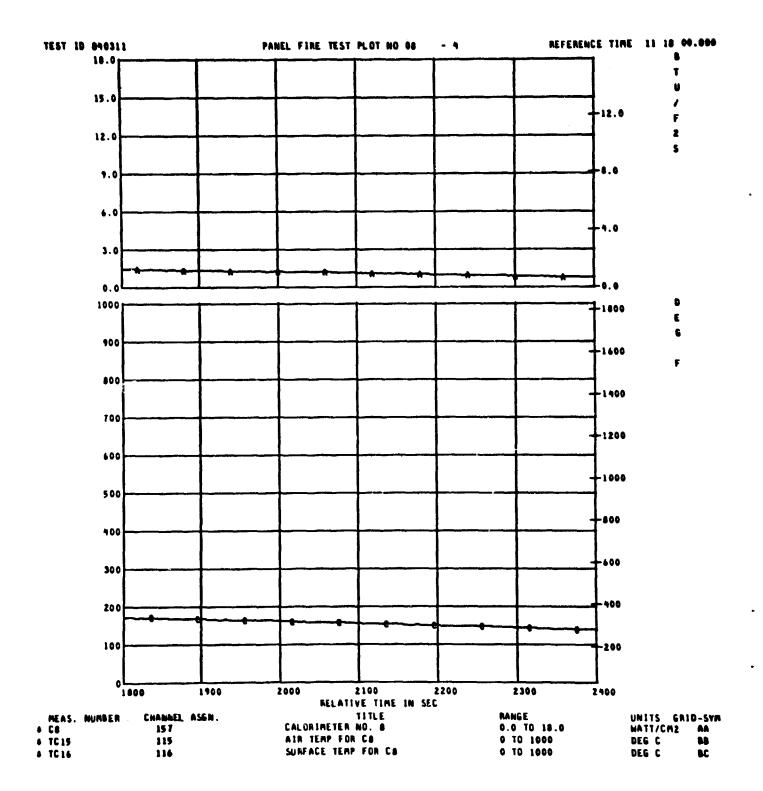


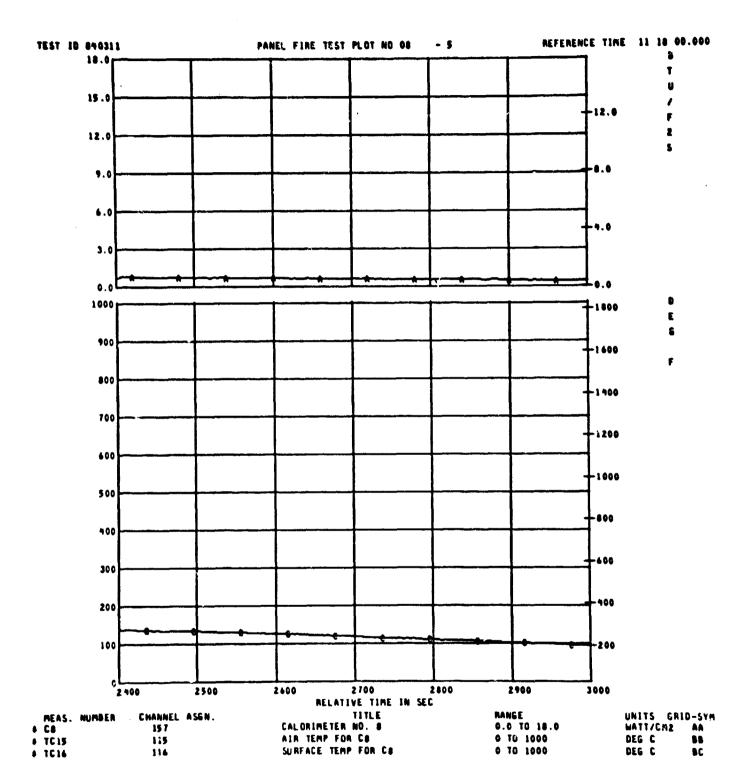


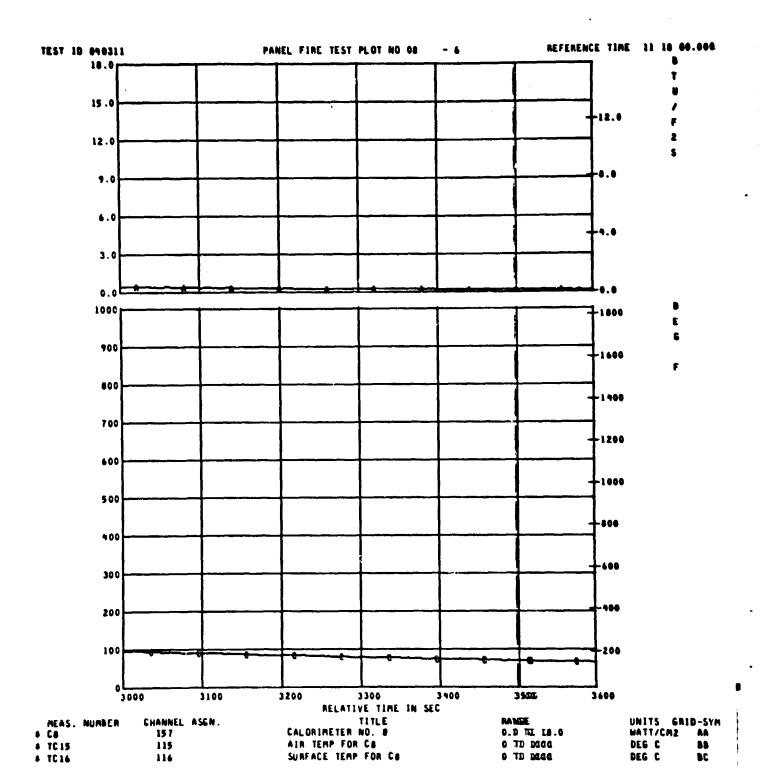


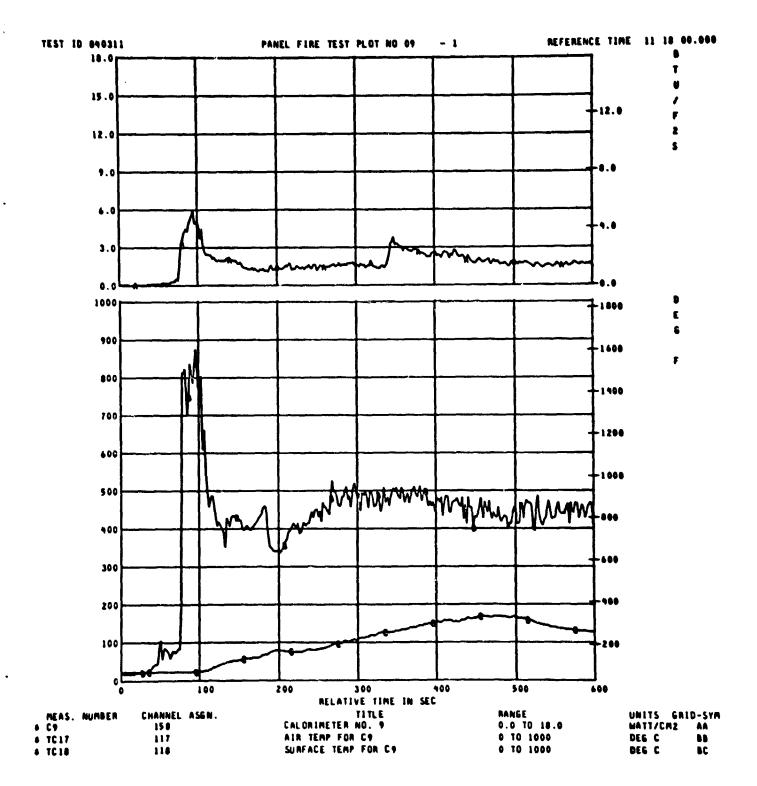


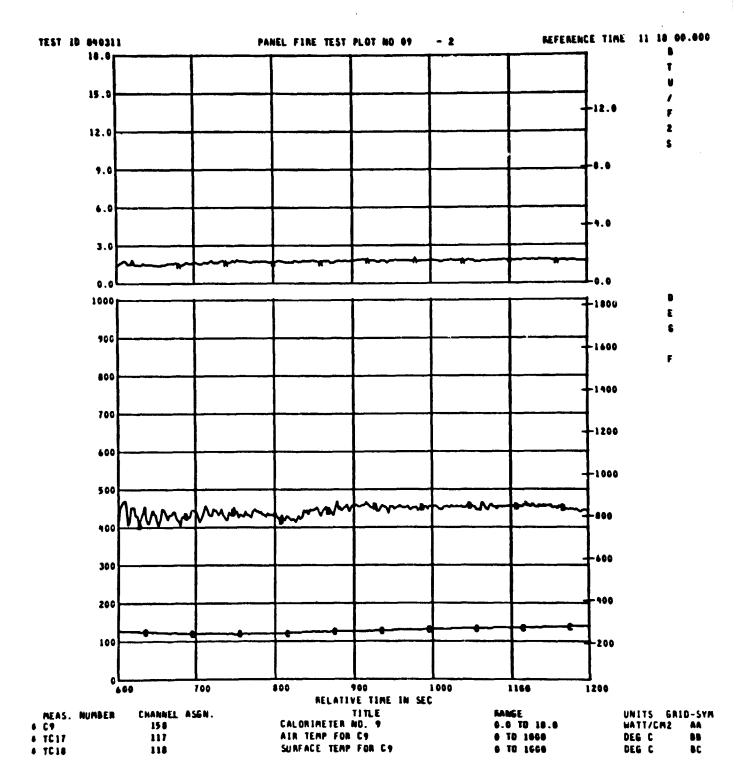
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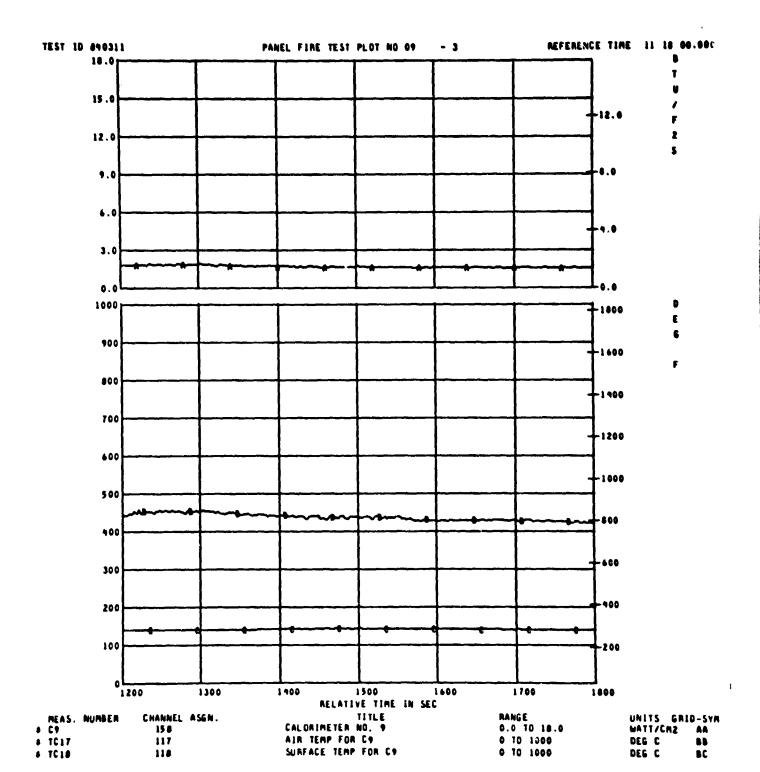


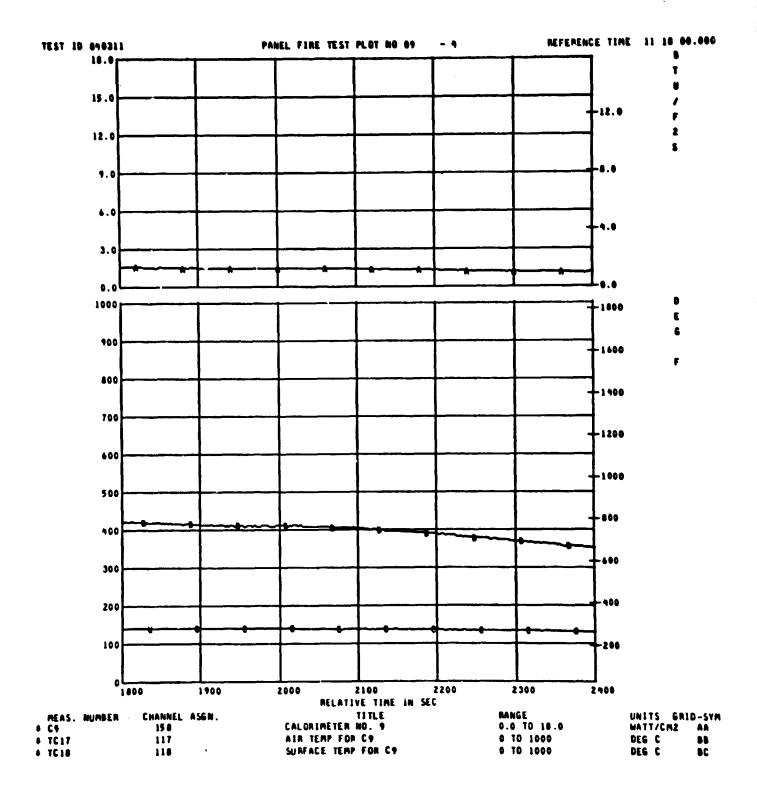


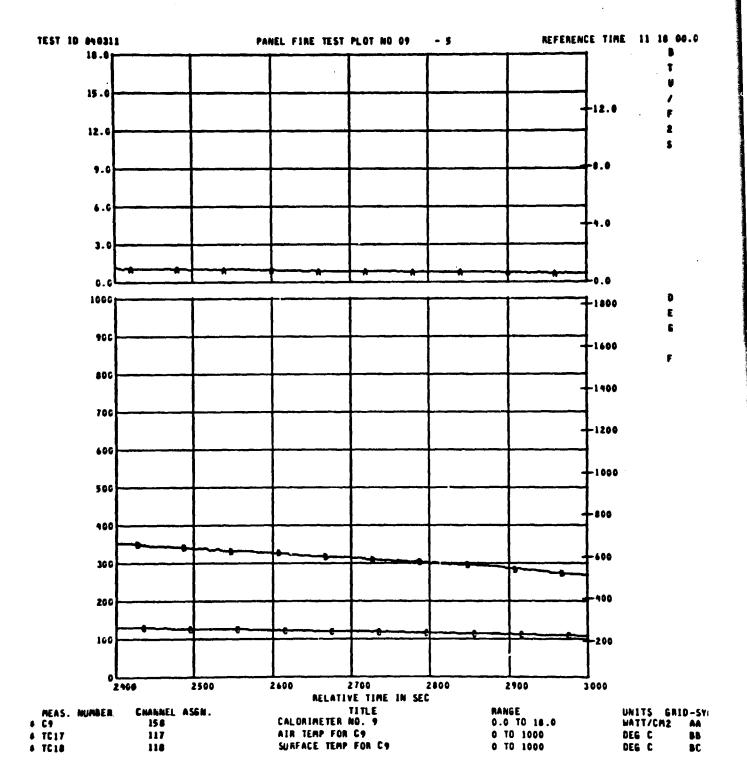


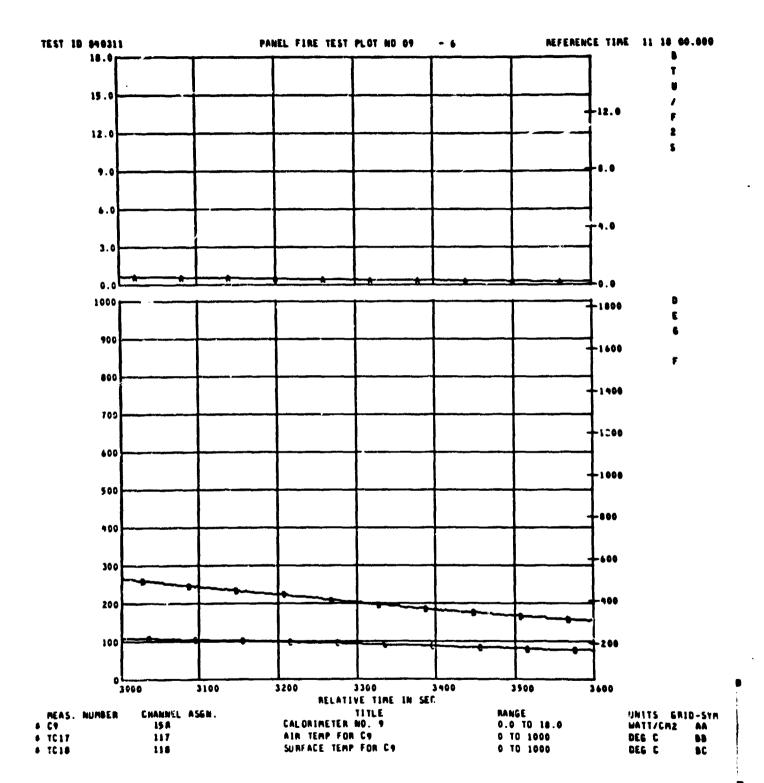


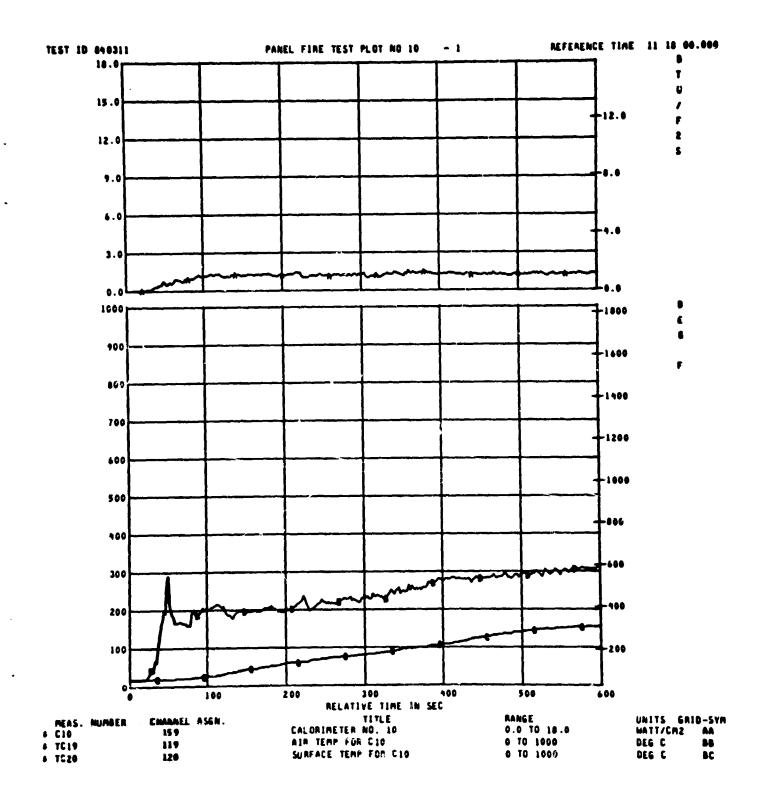


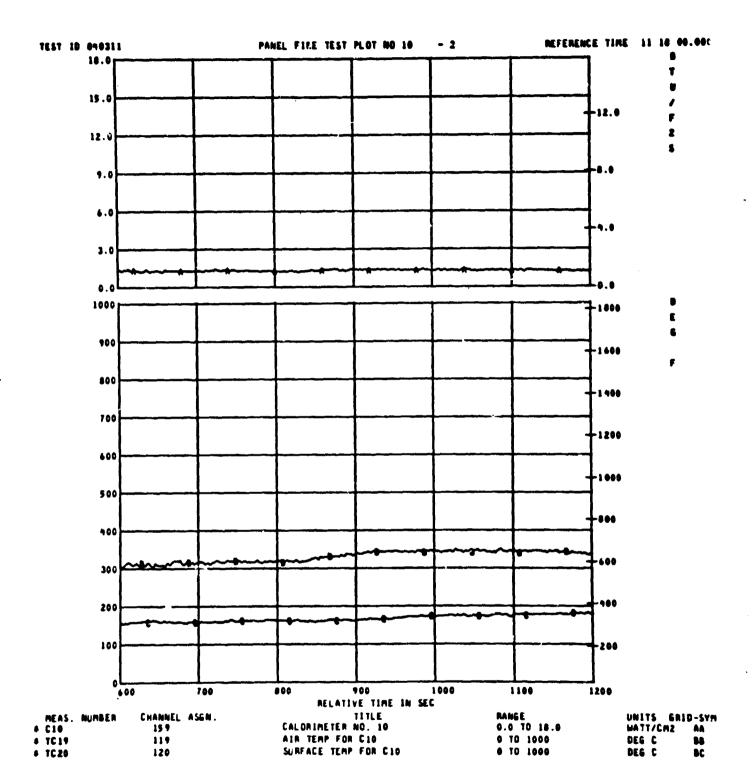


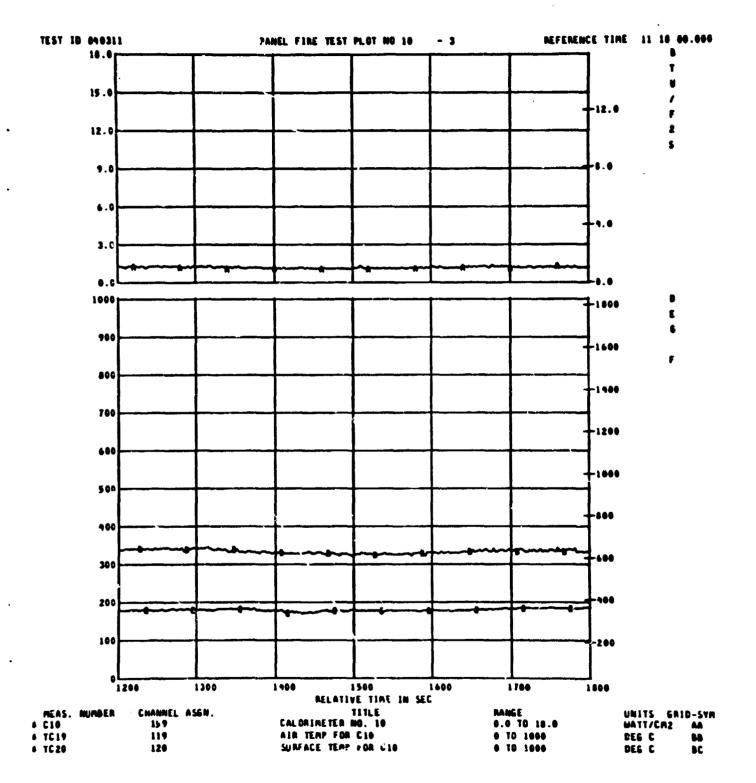


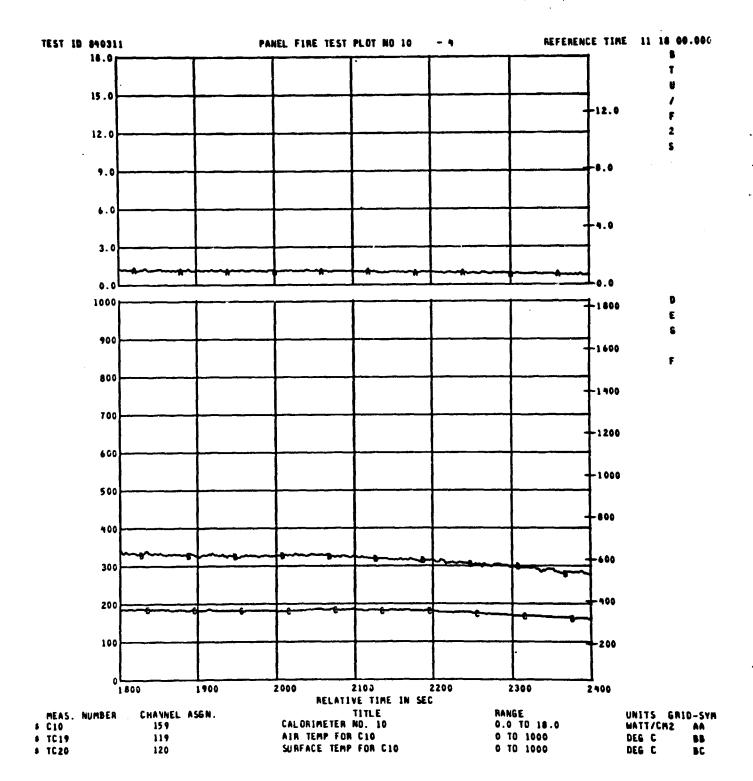


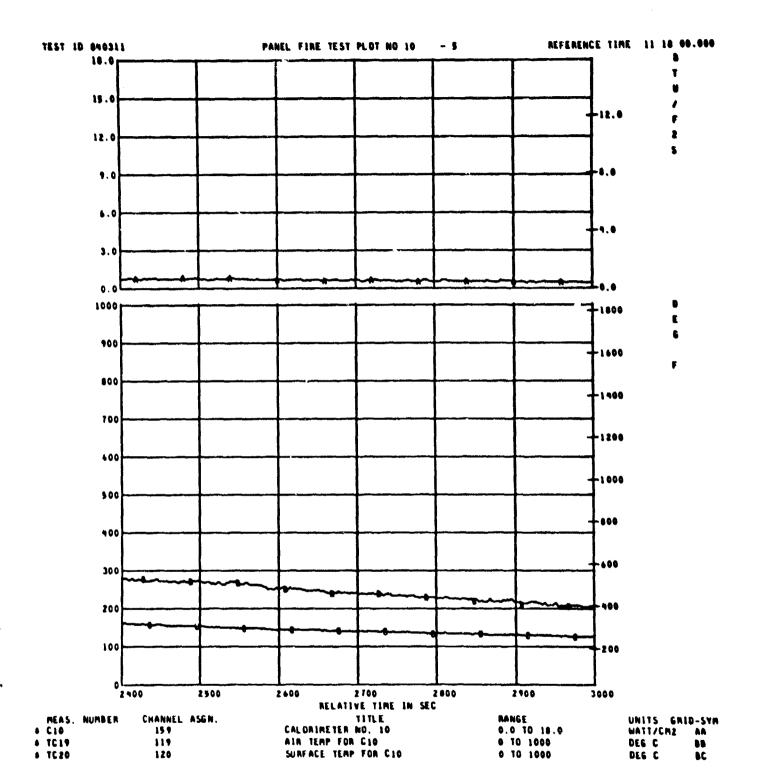


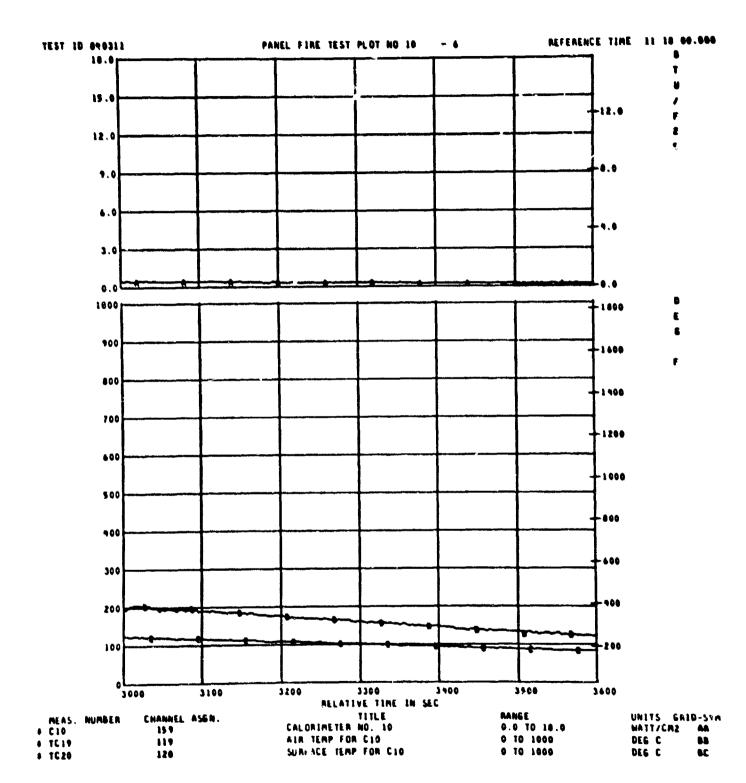


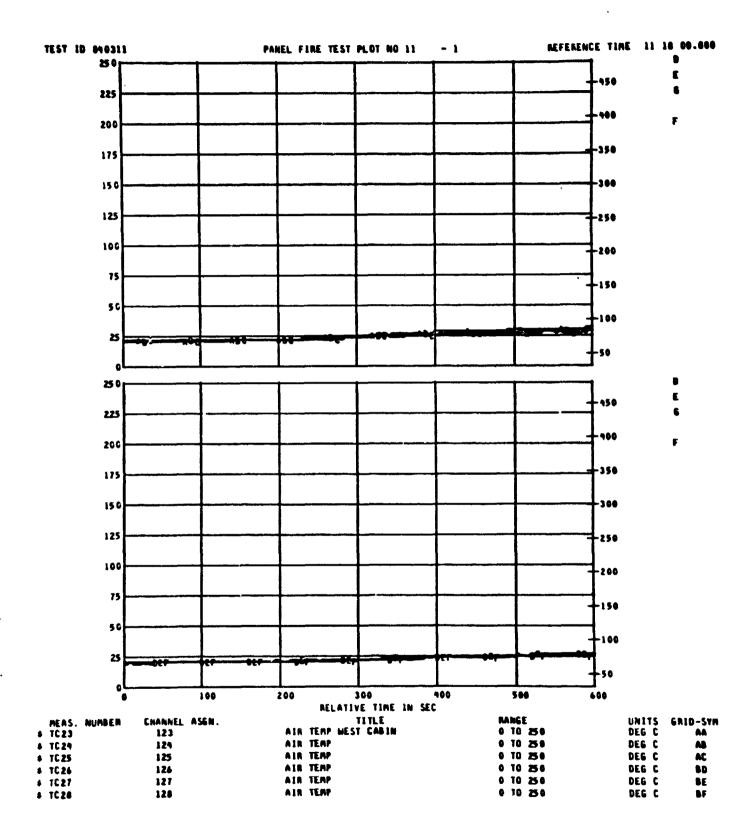


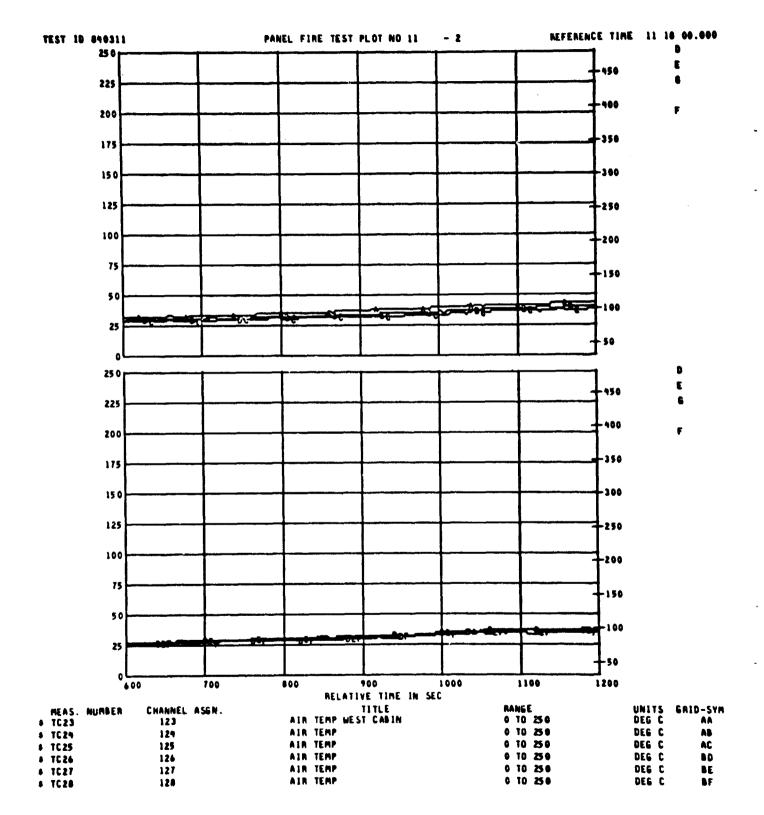


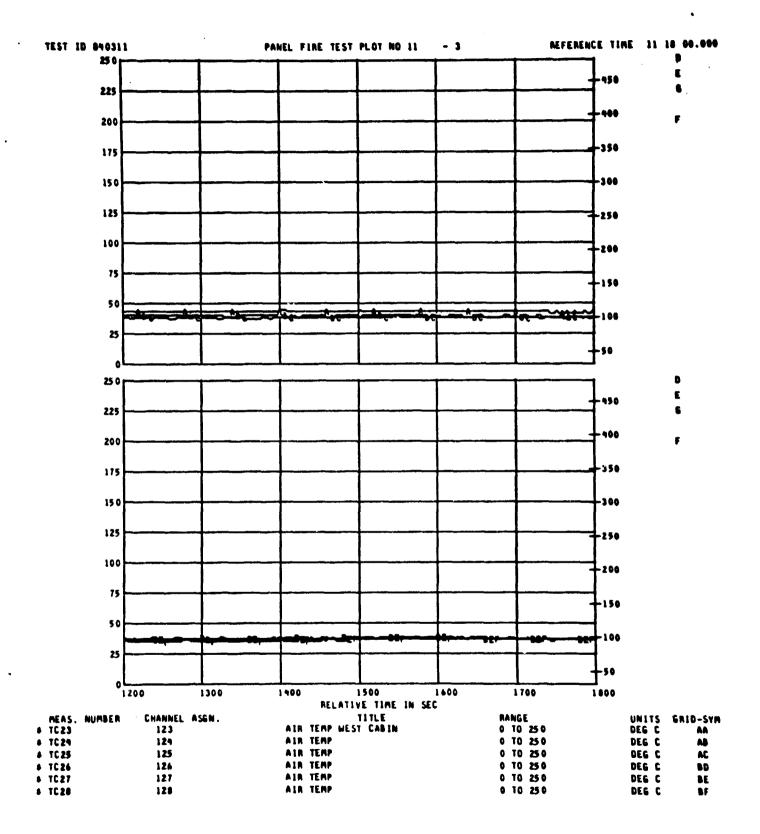


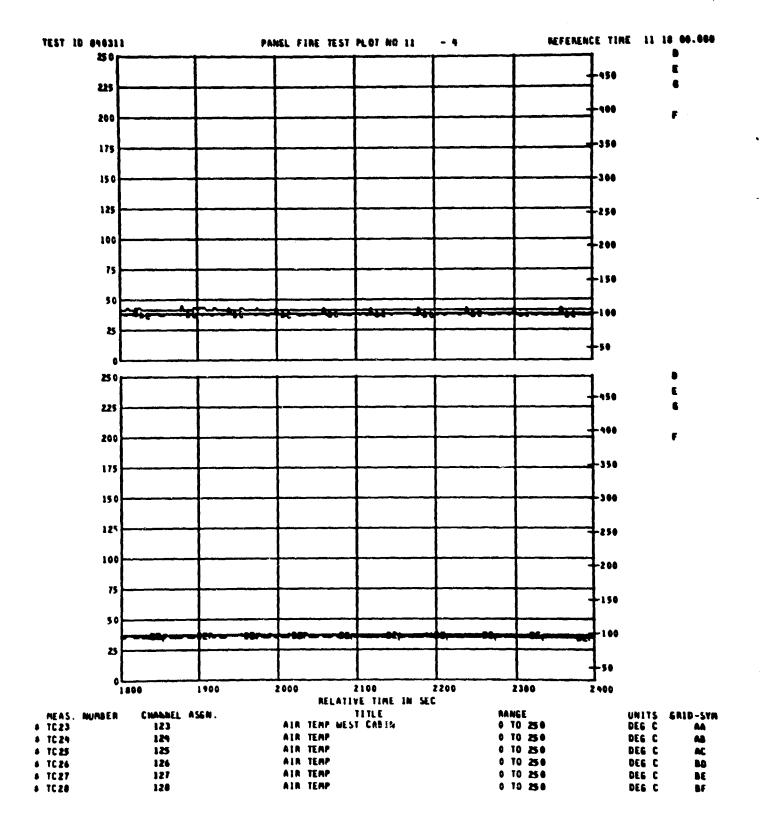


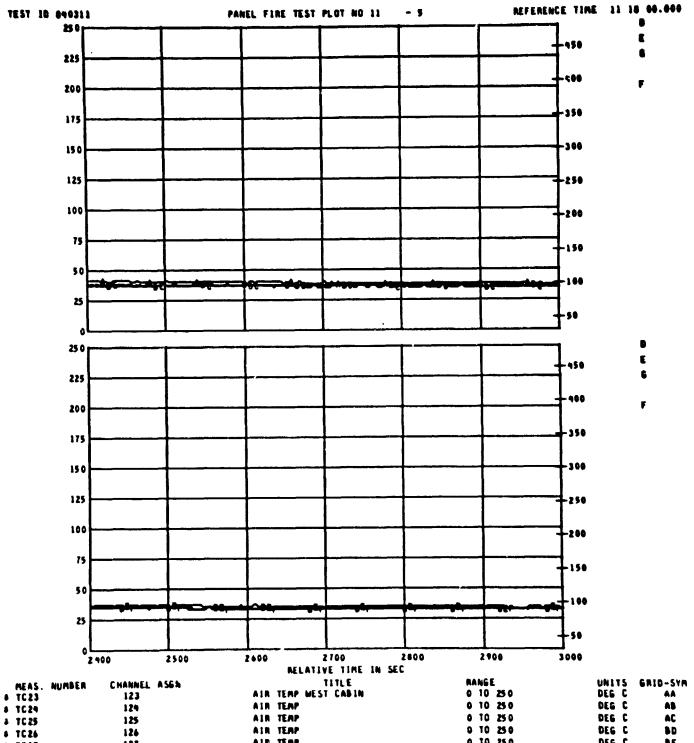




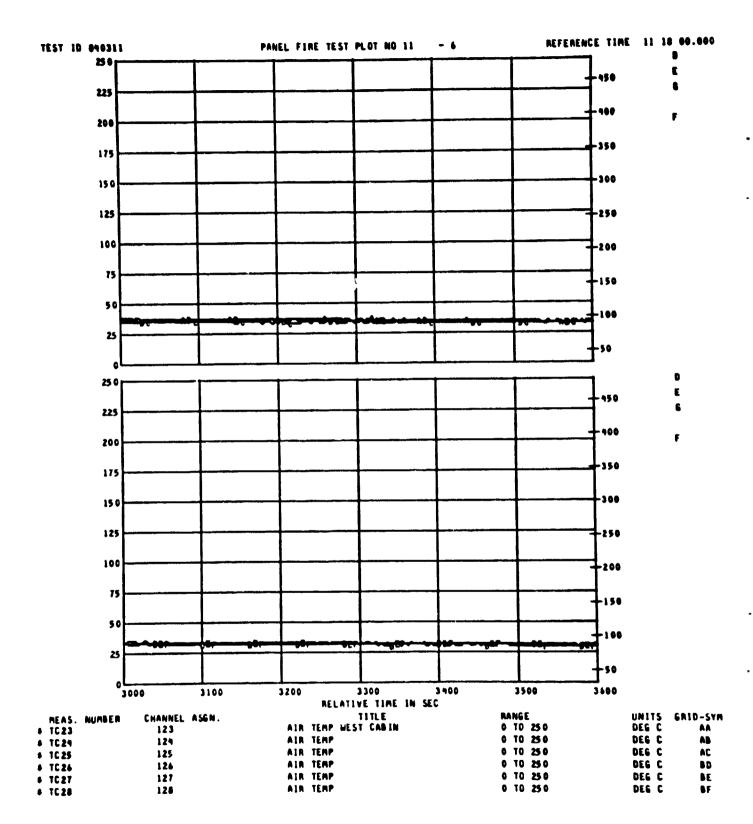


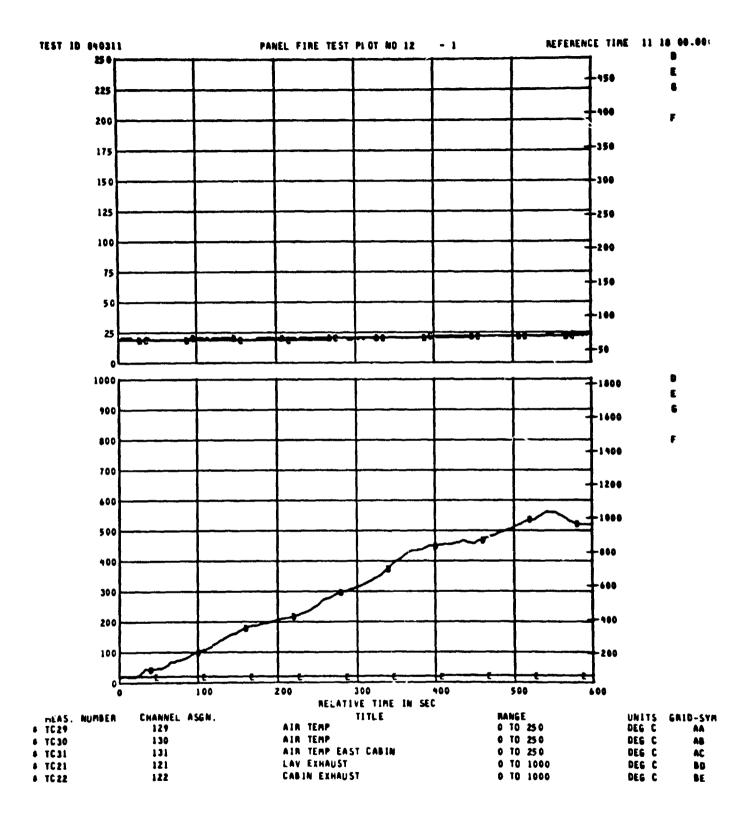


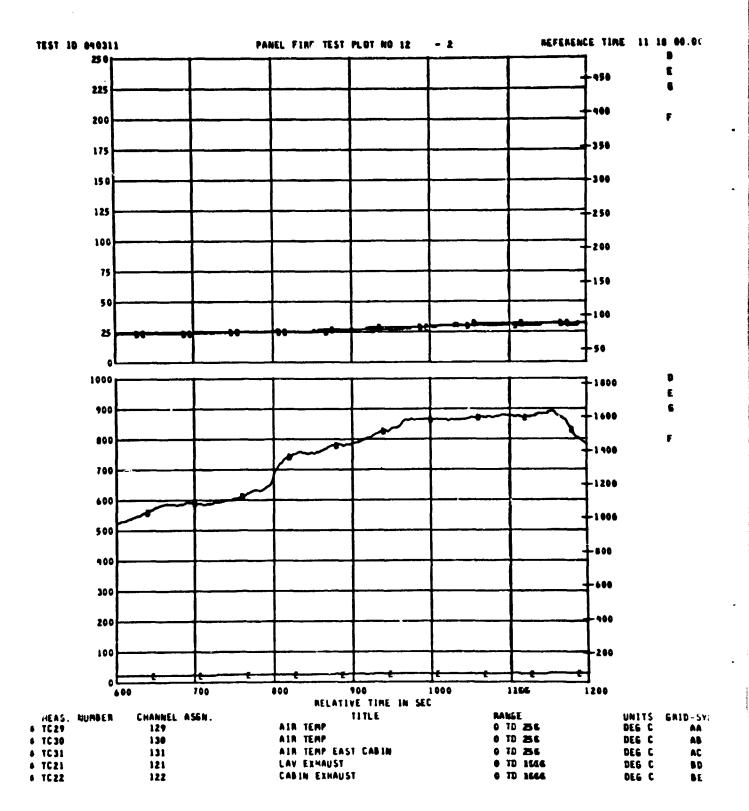




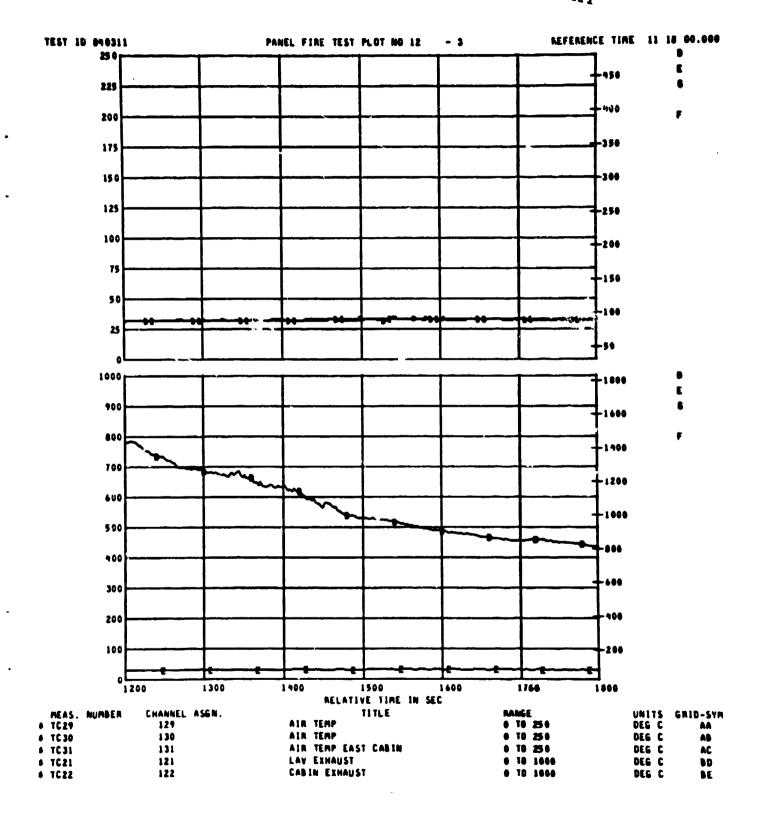
		WEEN 11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
MEAS. NUMBER	CHANNEL ASEA	TITLE	RANGE	UNITS GRID-SYM
+ TC23	123	AIR TEMP WEST CABIN	0 10 25 0	DEG C AA
4 TC24	129	AIR TEMP	0 10 25 0	DEG C AB
\$ TC25	125	AIR TEMP	0 10 250	DES C AC
6 TC26	126	AIR TEMP	9 10 25 0	DEG C BD
6 TC27	127	AIR TEMP	0 10 25 0	DEG C BE
· · ·	120	AIR TEMP	0 TO 25 O	DEG C BF
* 1C58	***			

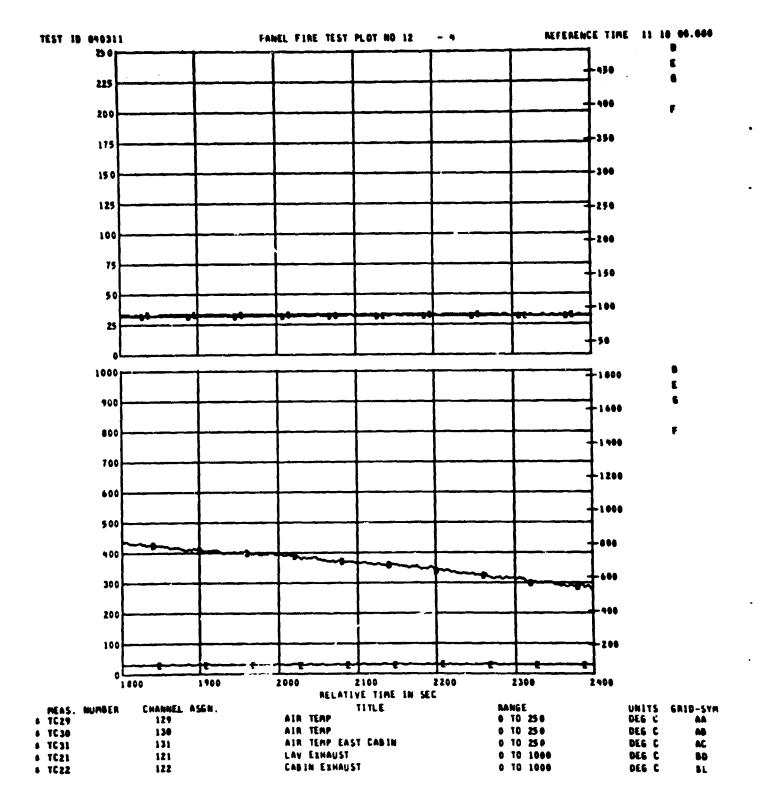


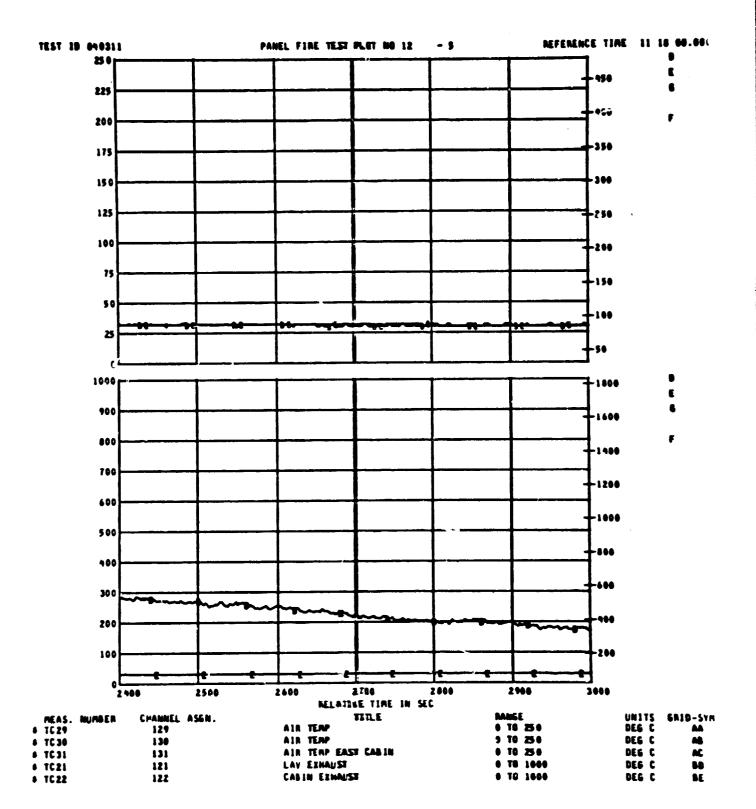


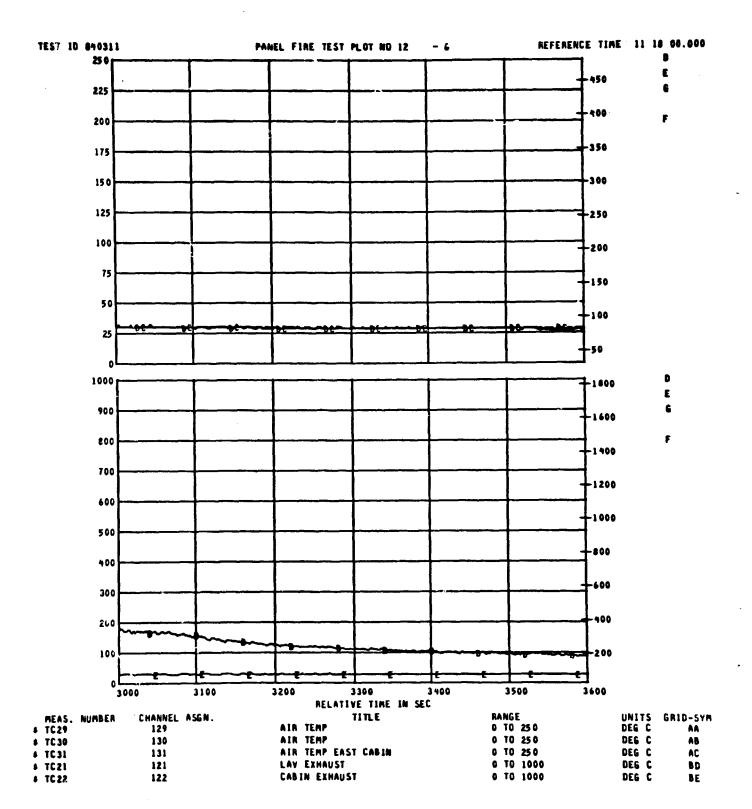


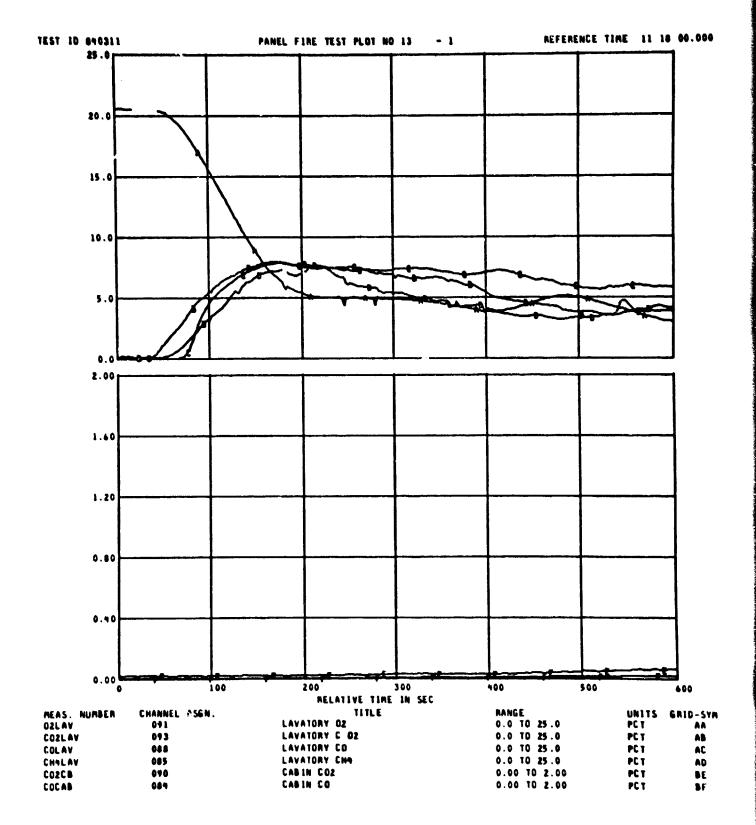
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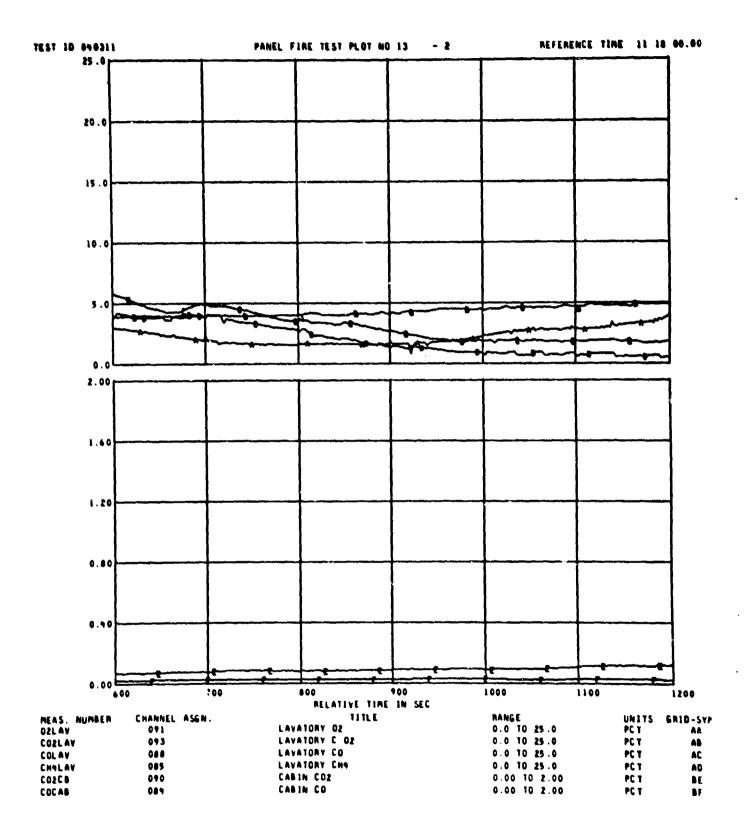


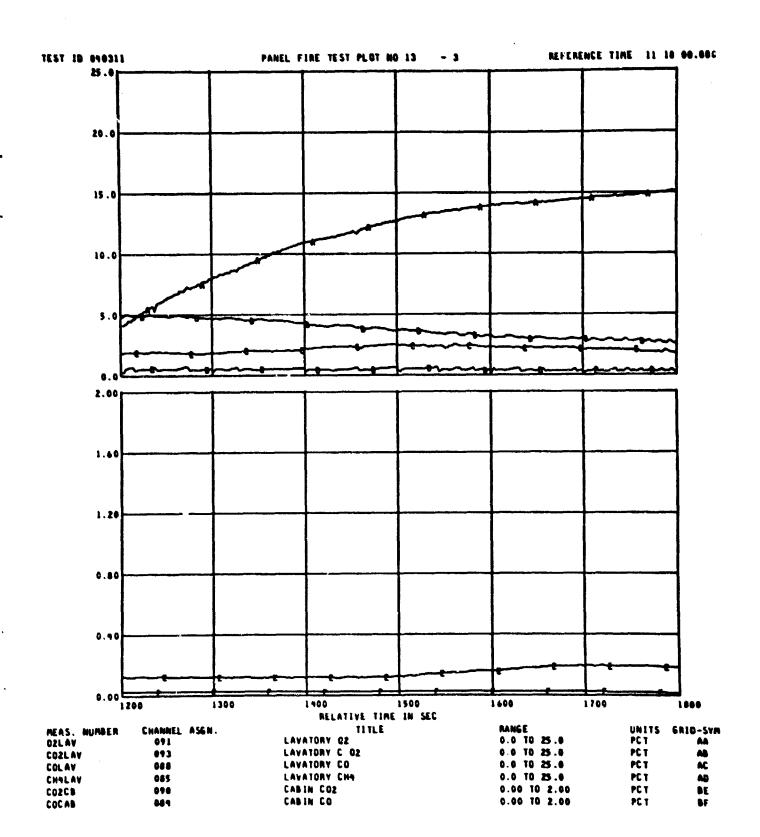


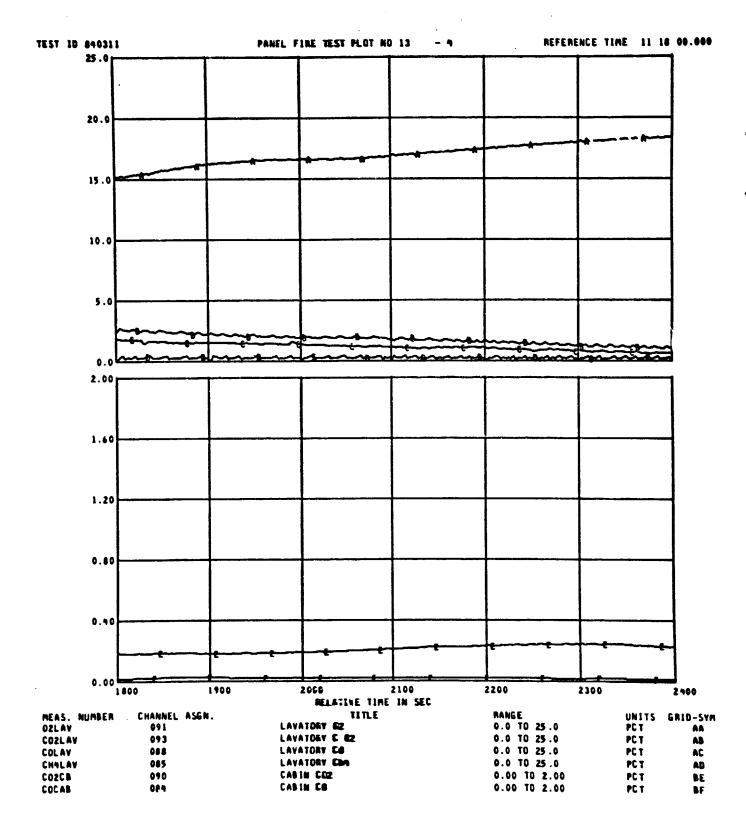


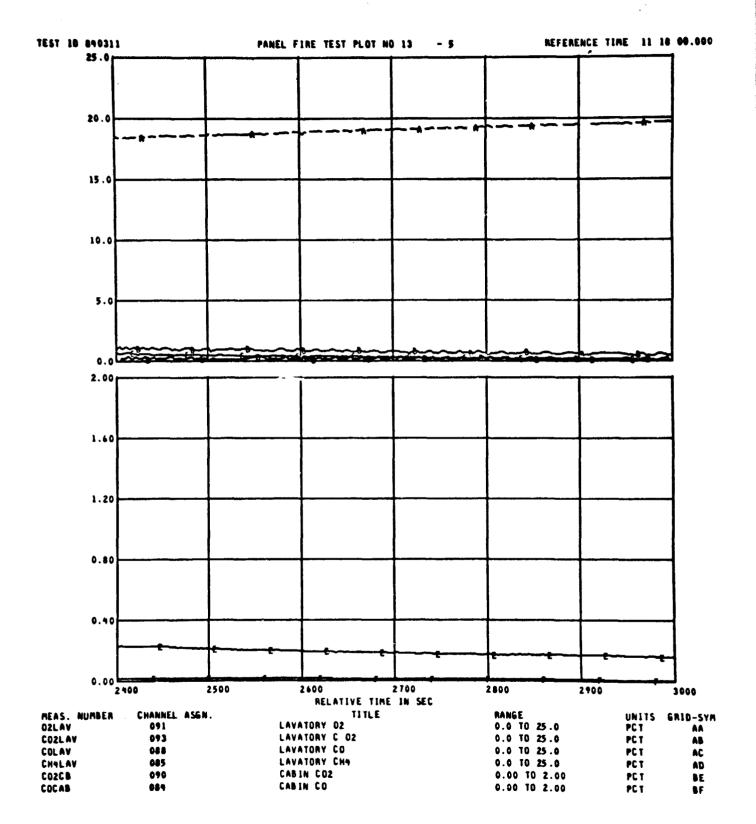




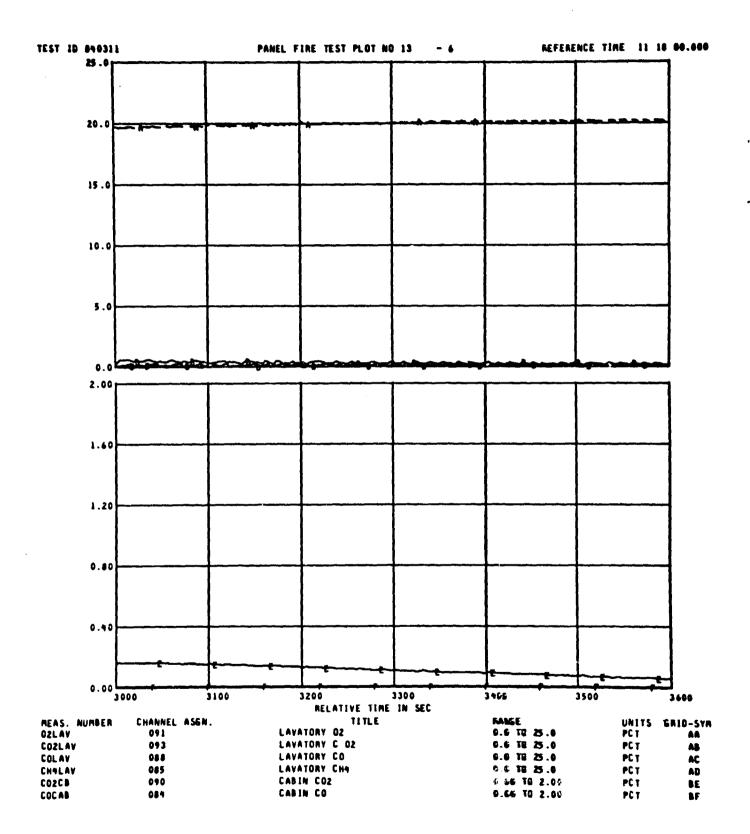




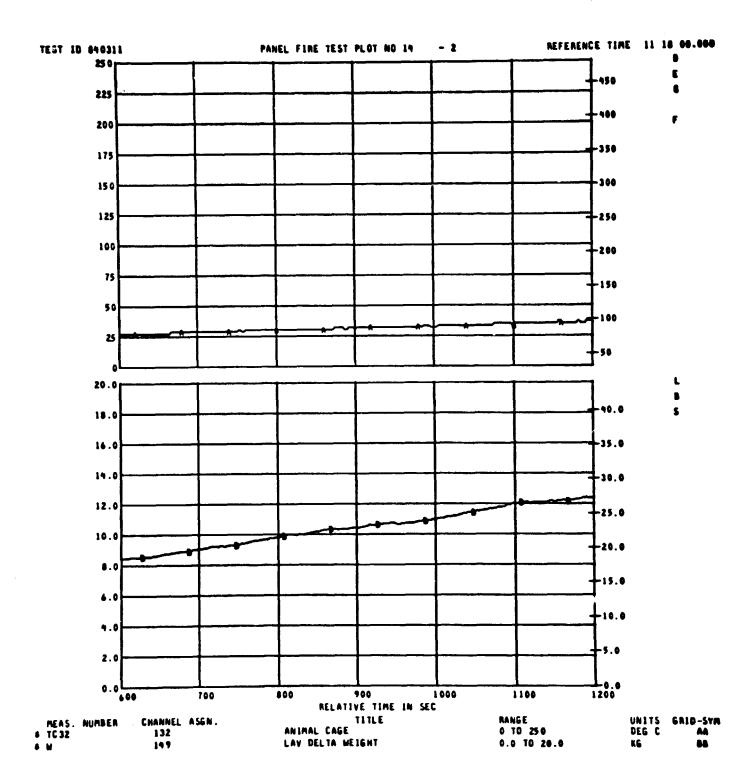


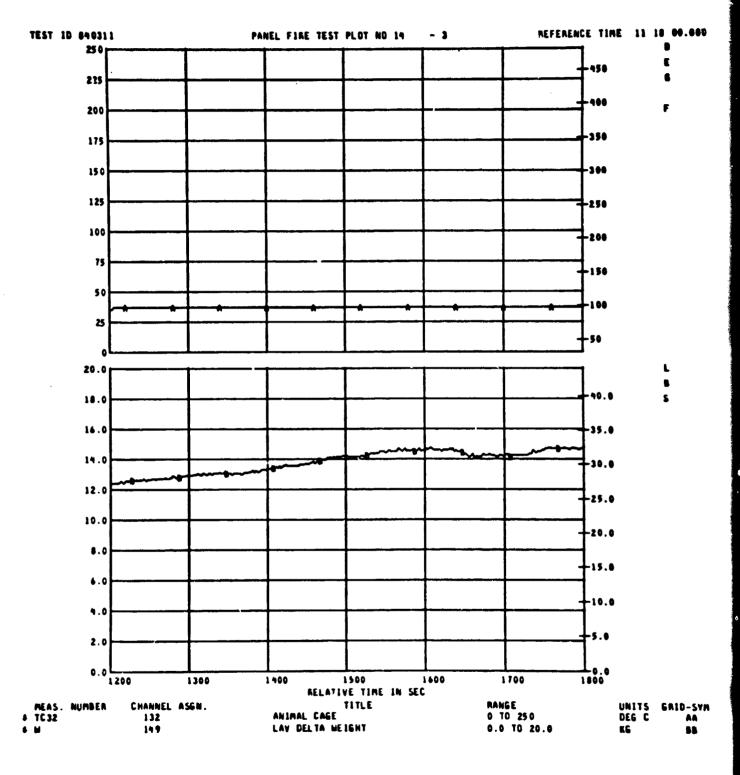


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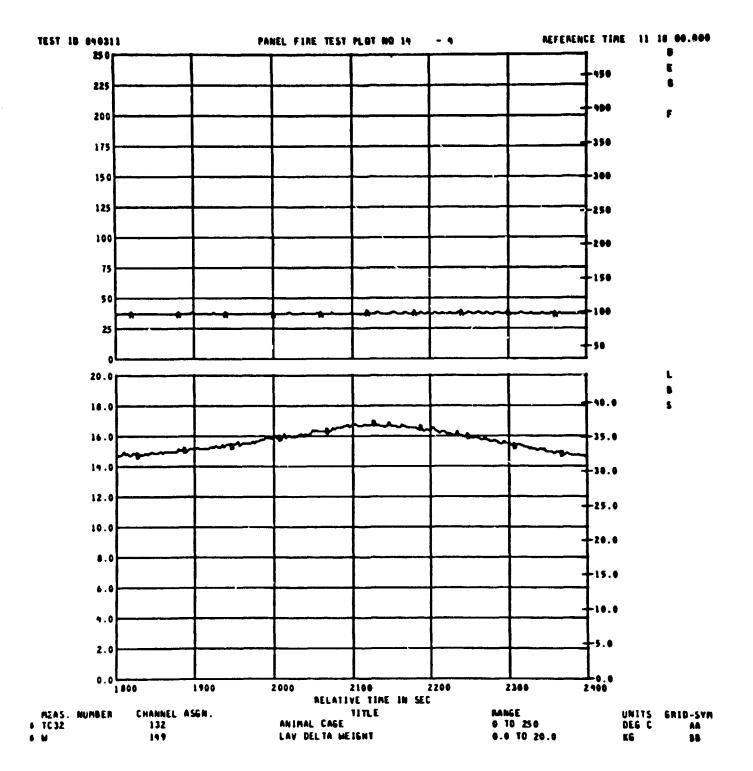


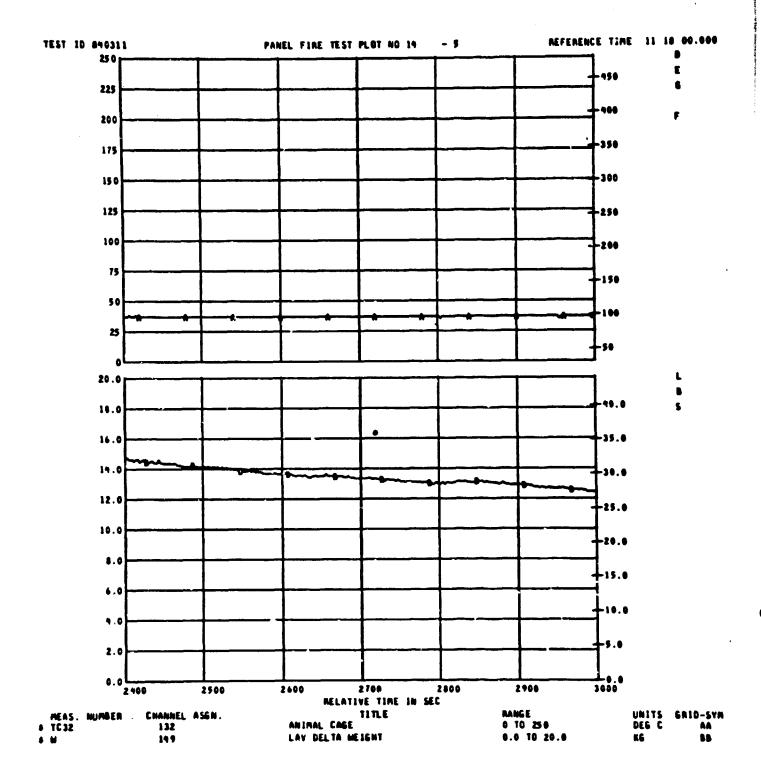
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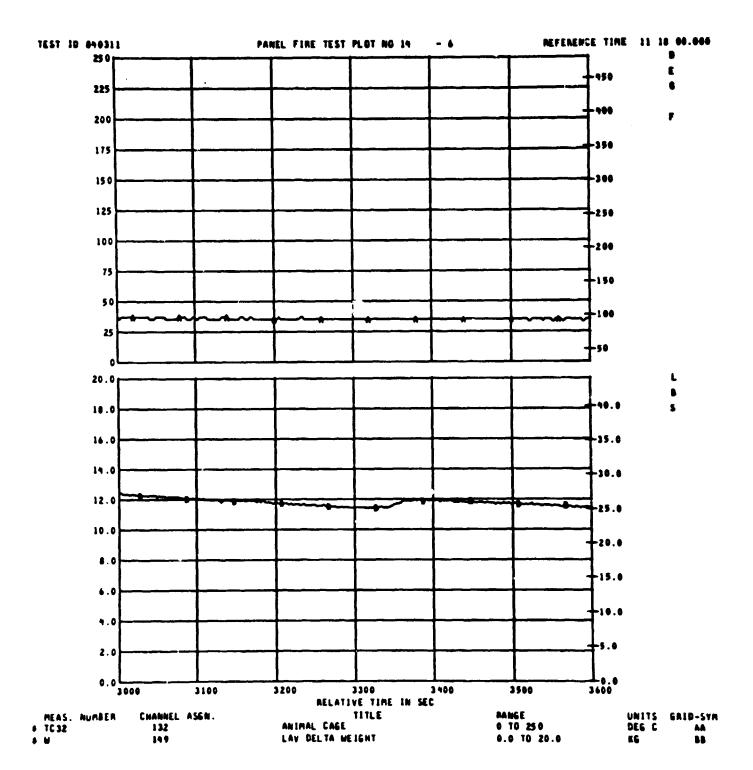


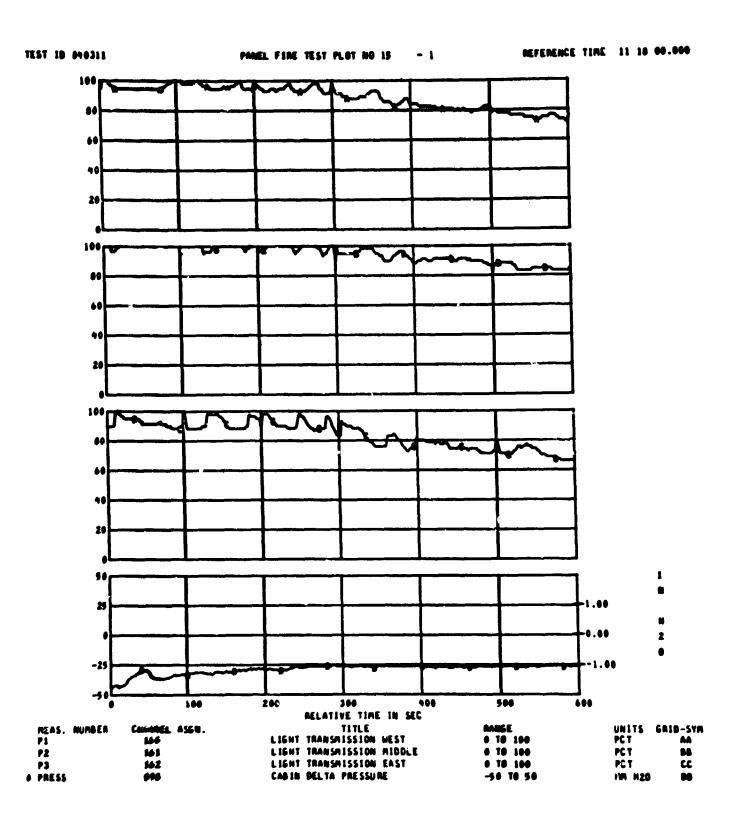


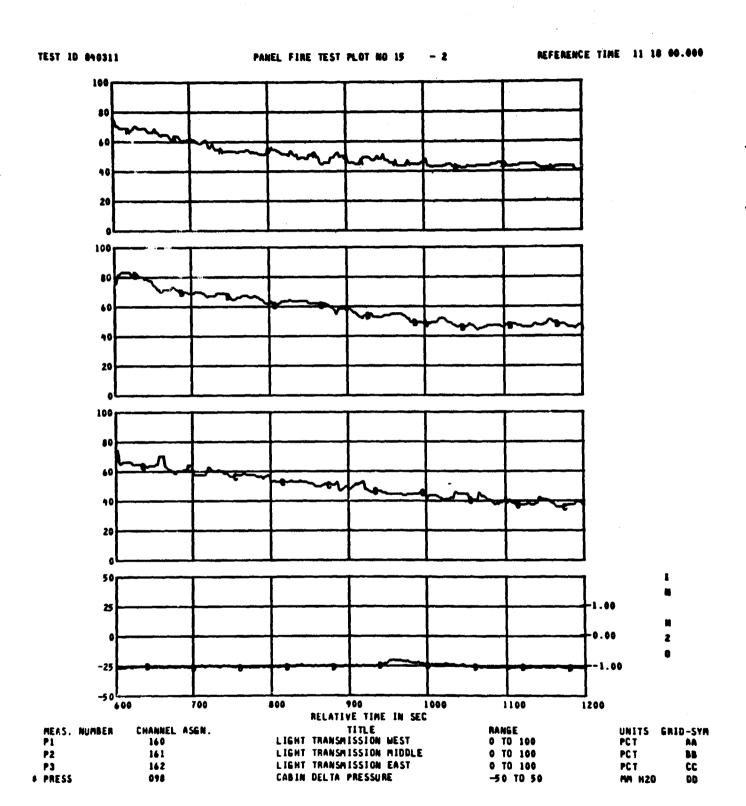
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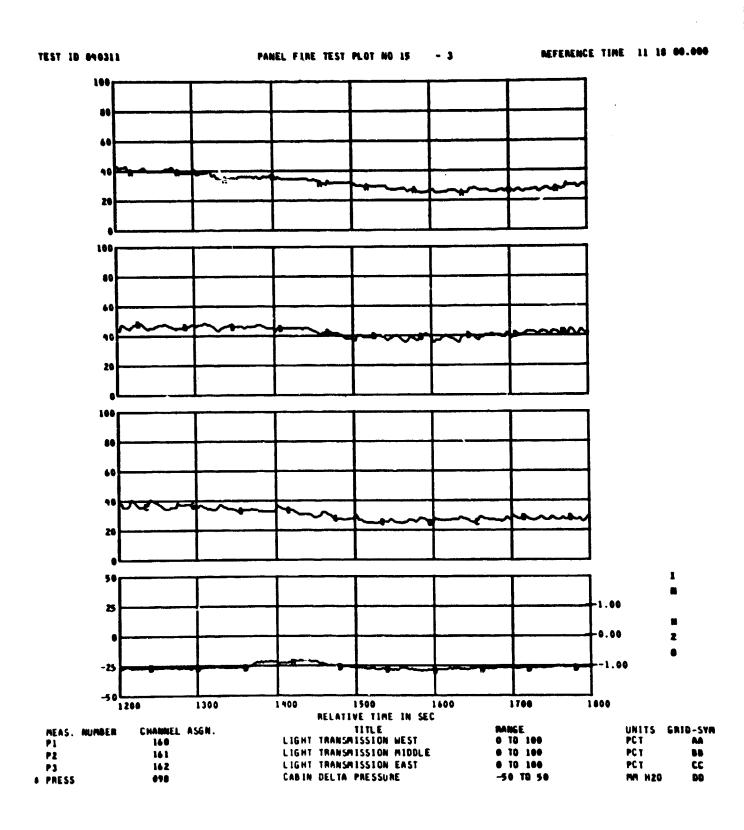


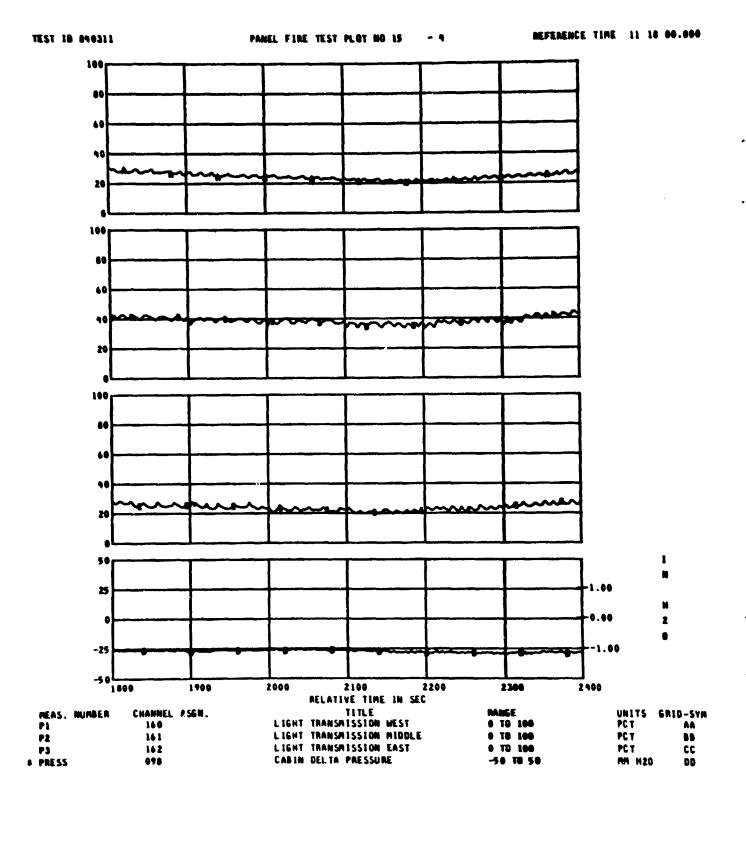


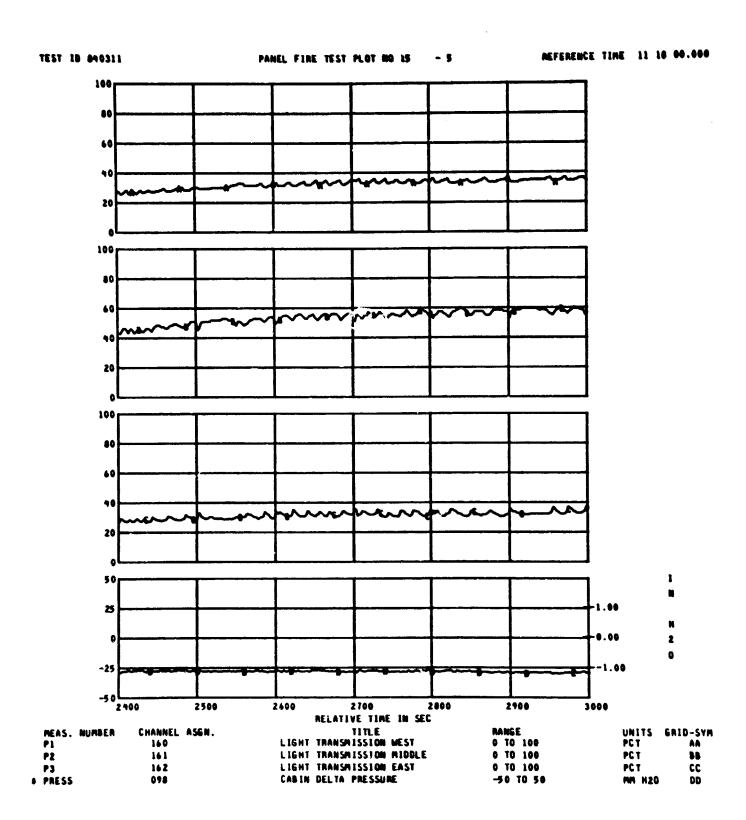


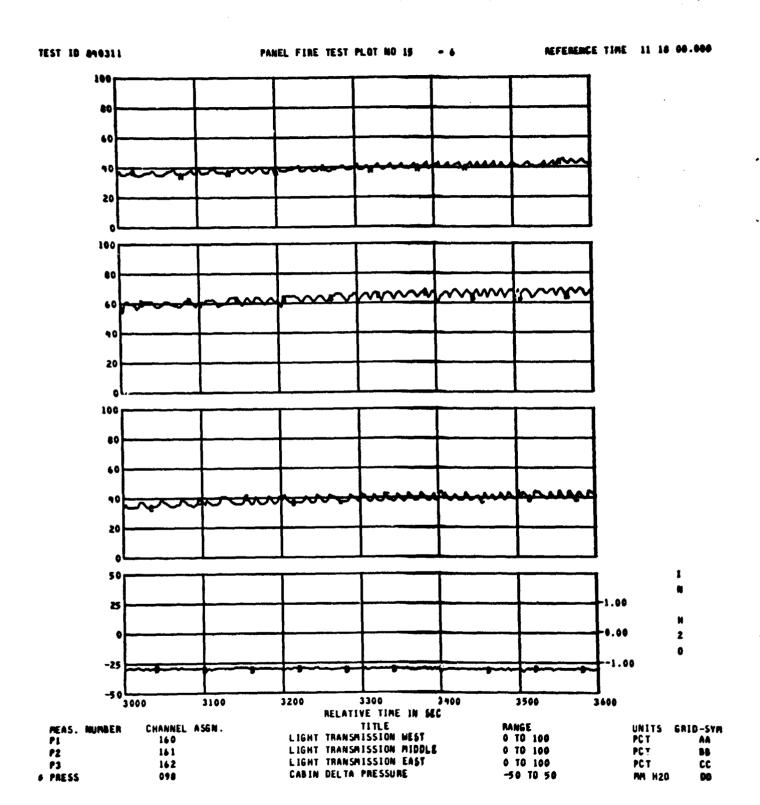




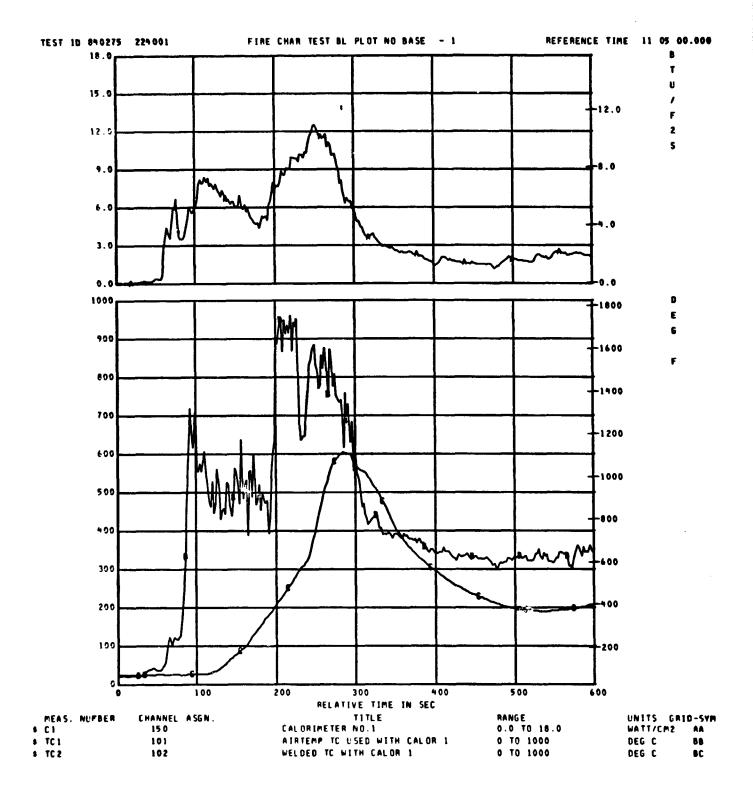




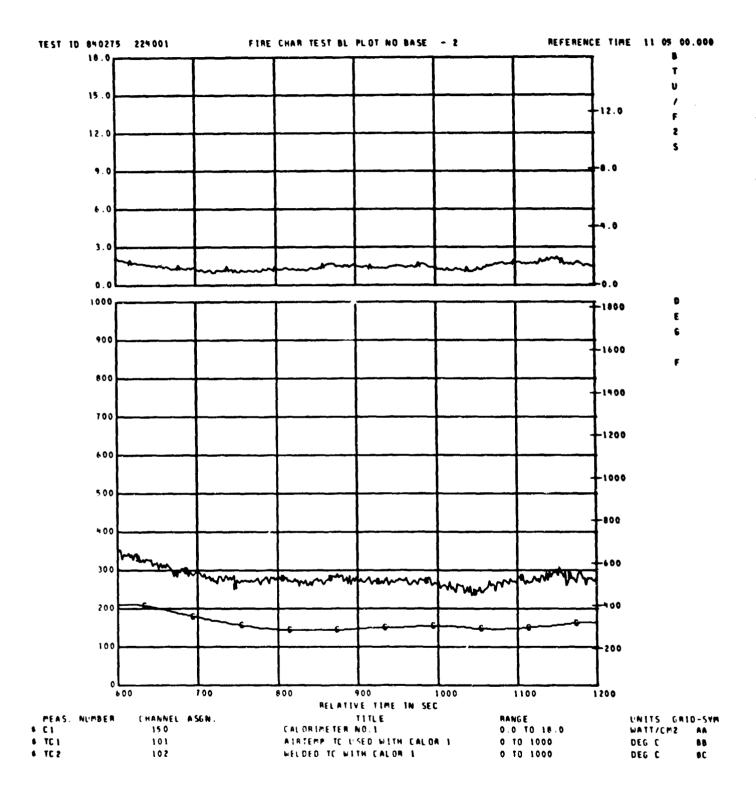


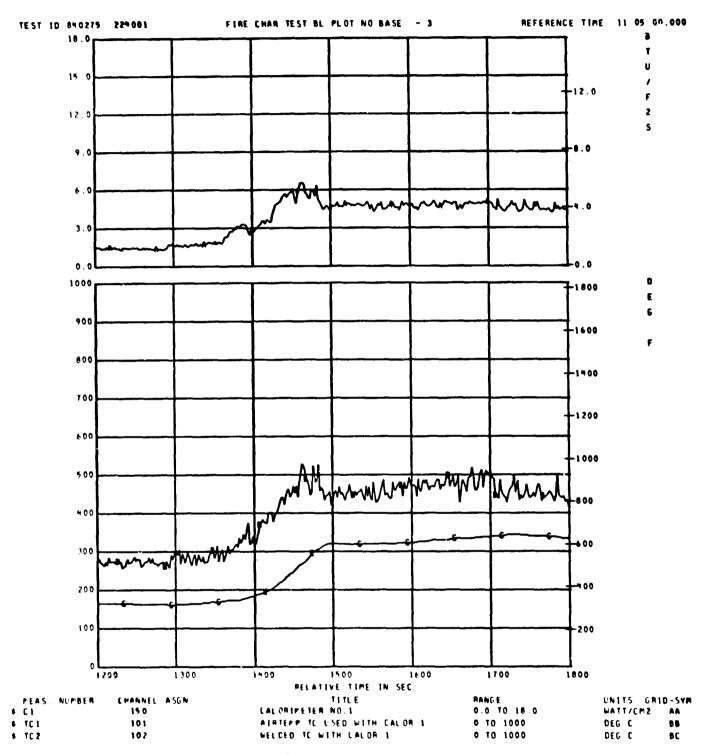


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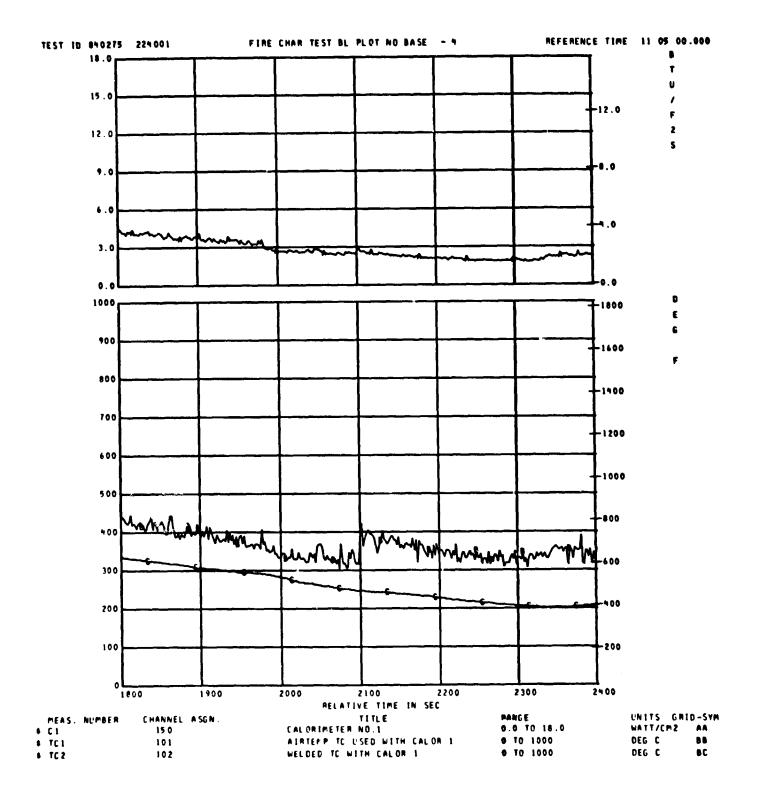


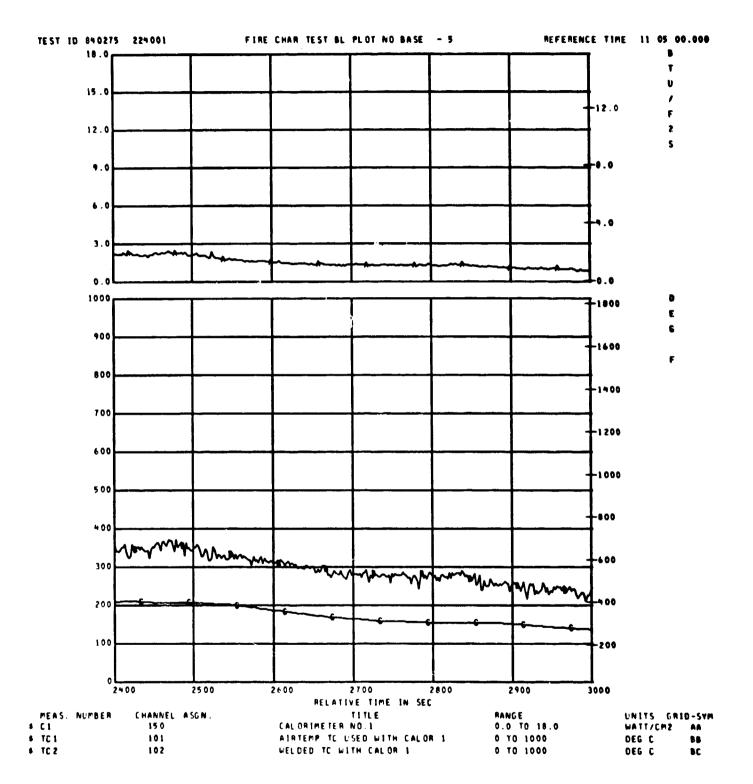
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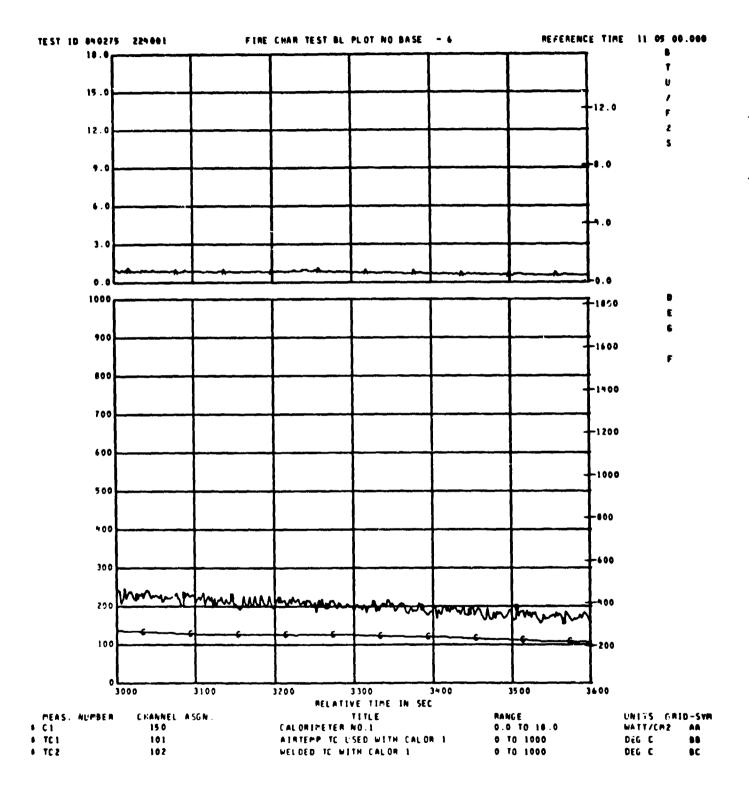


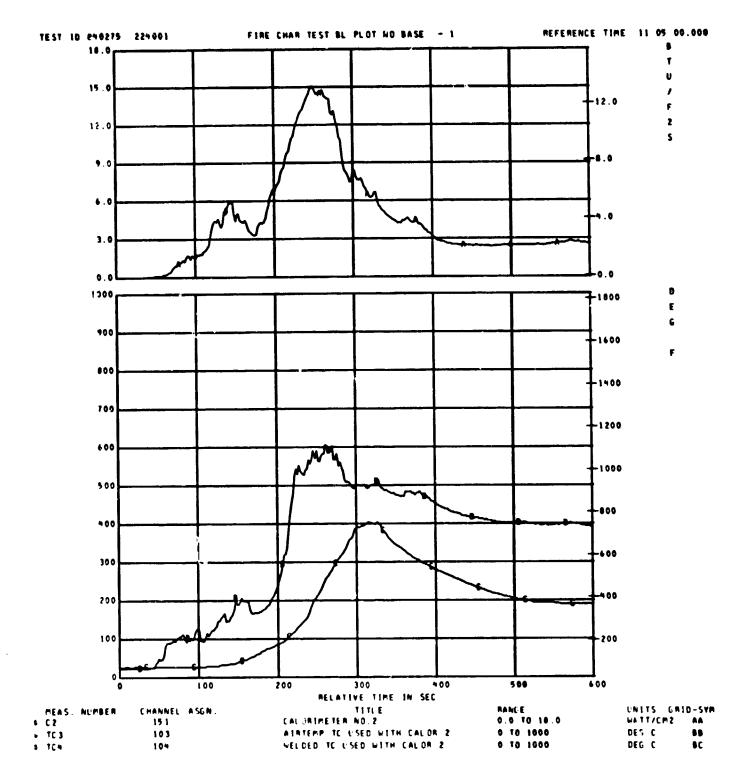


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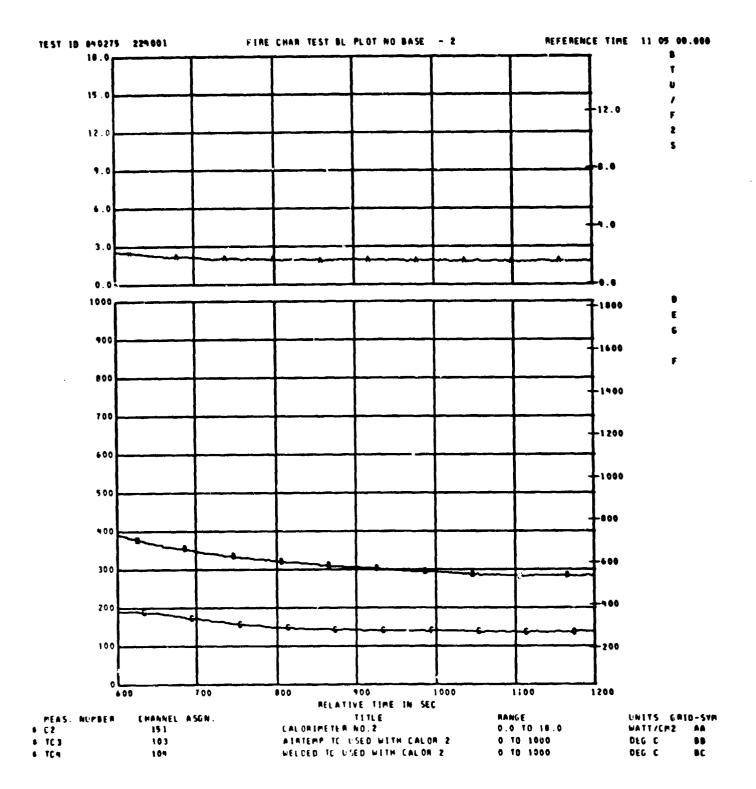


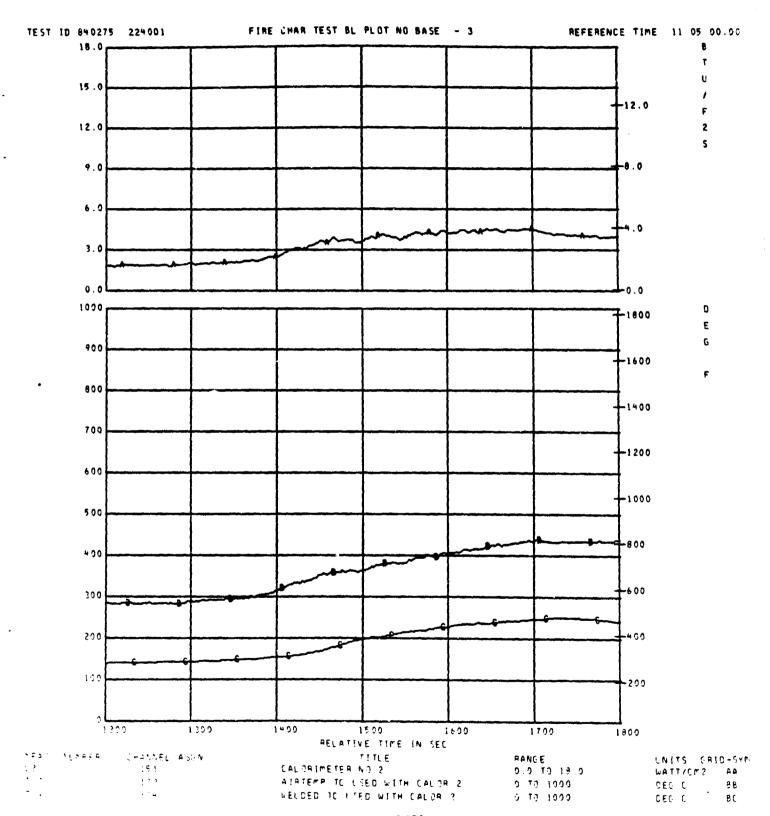


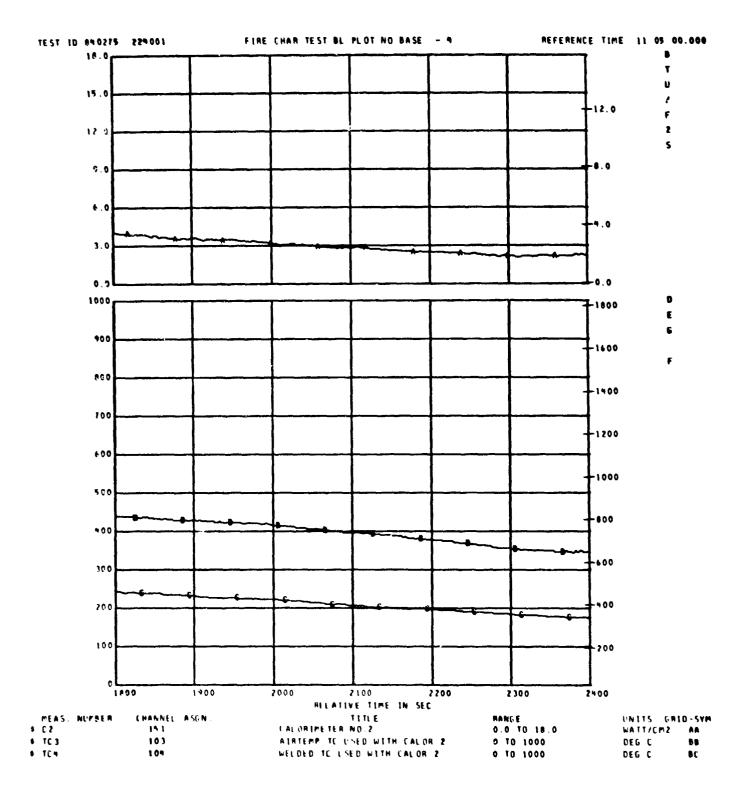




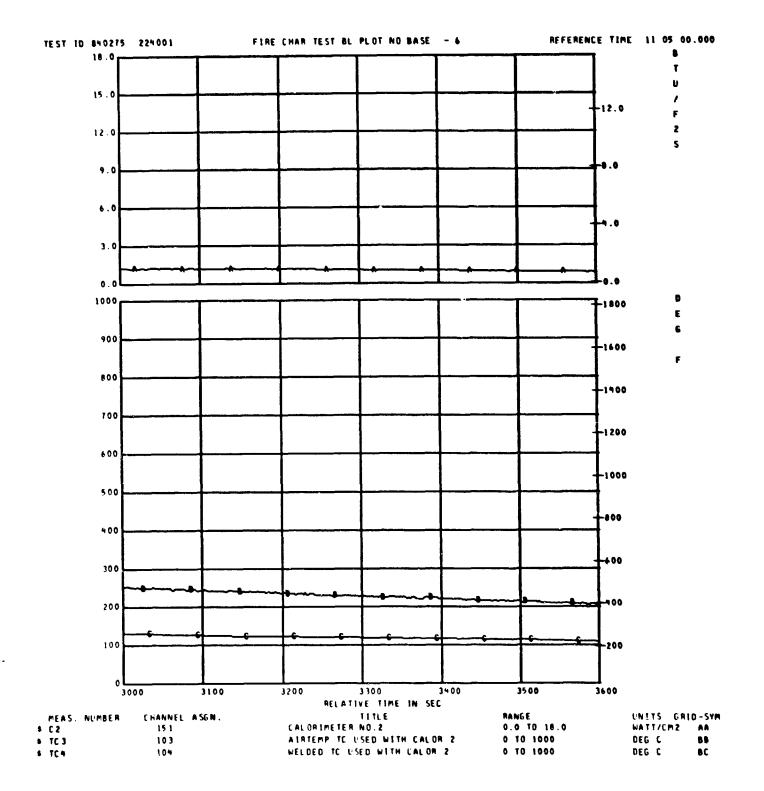
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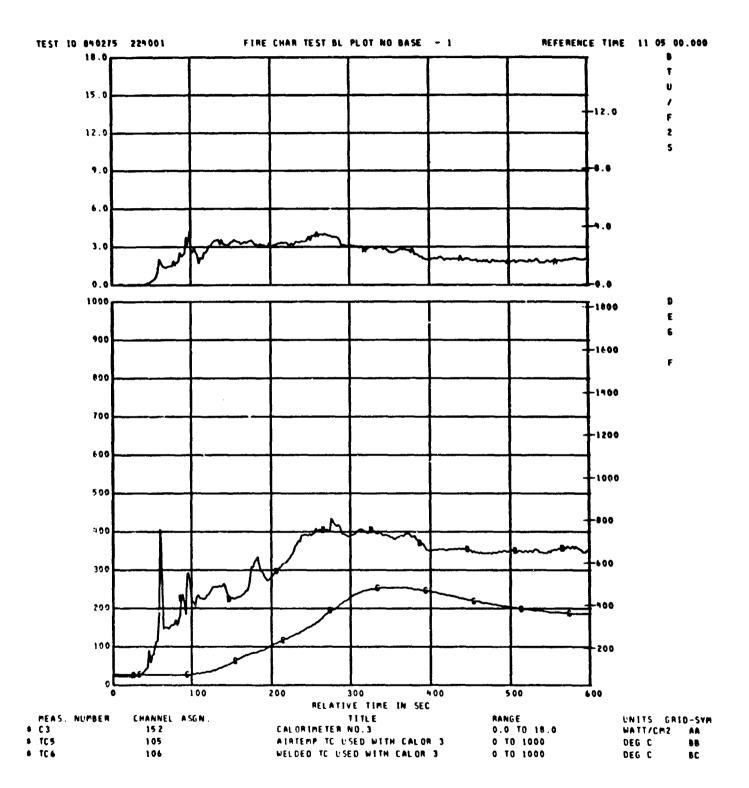


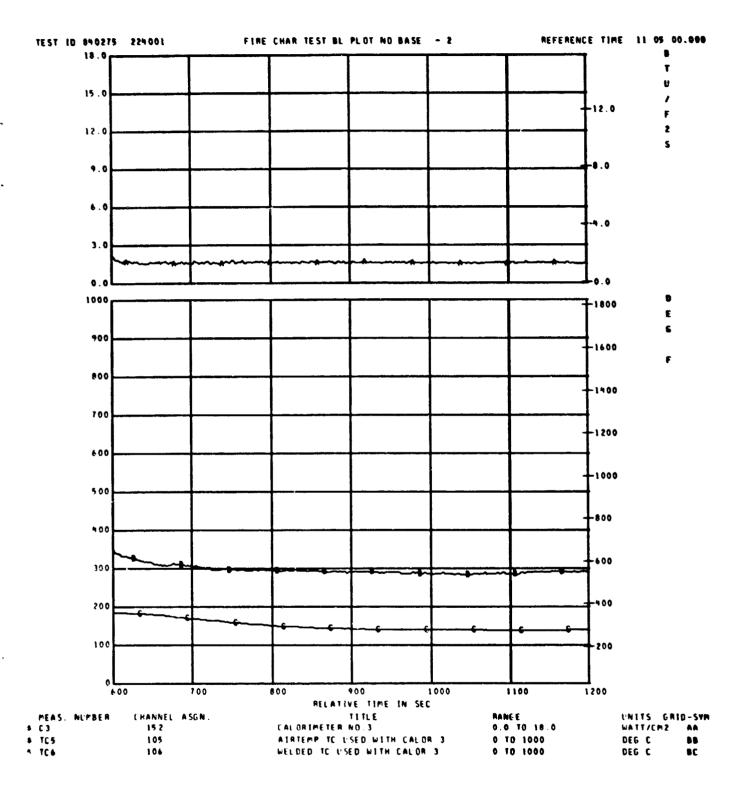


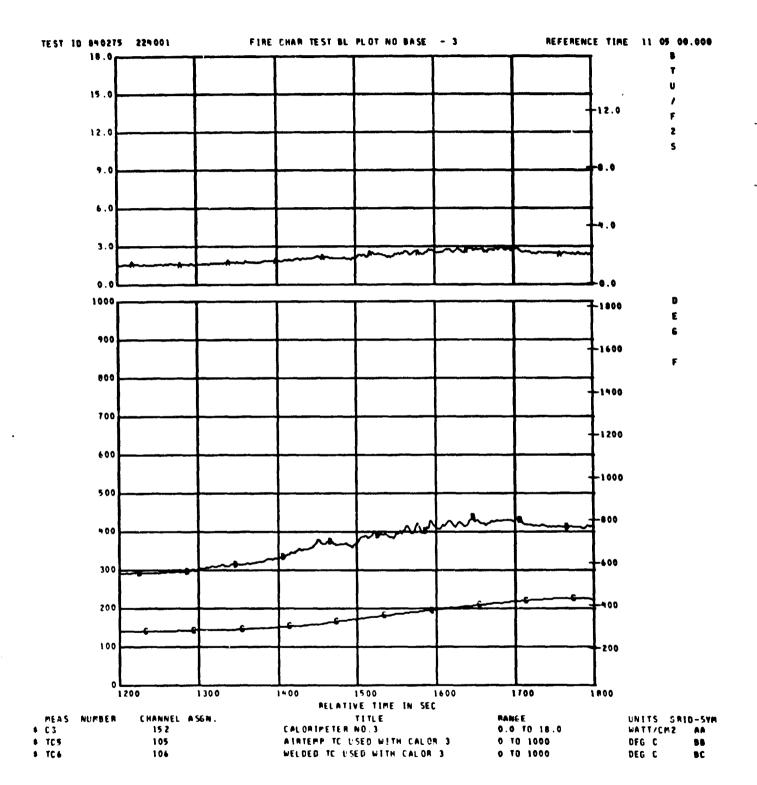


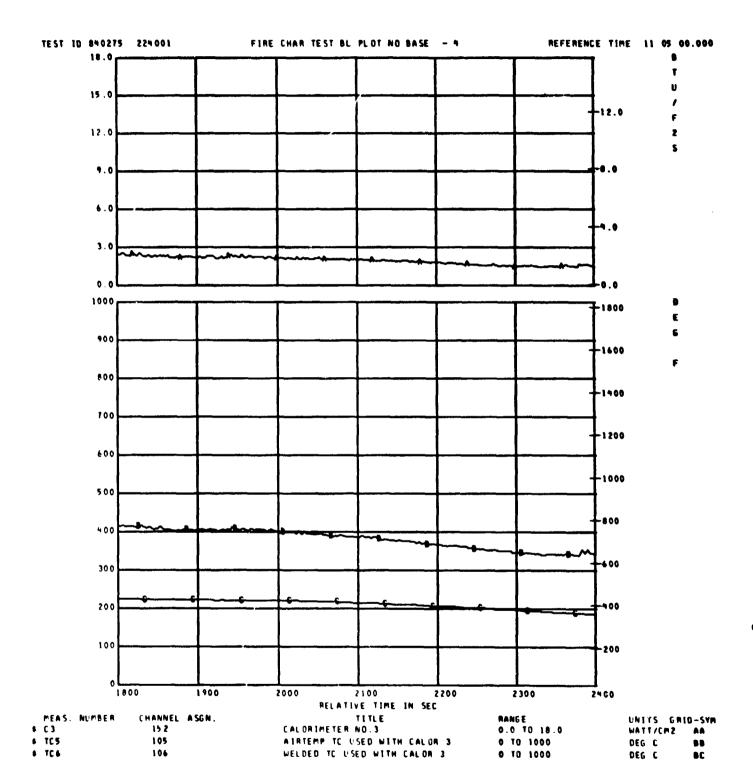
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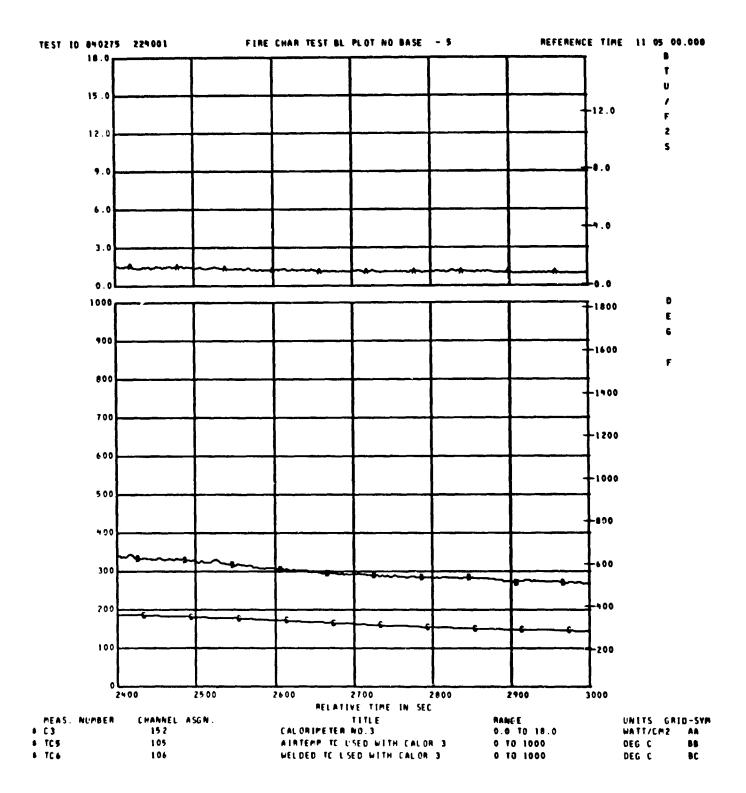


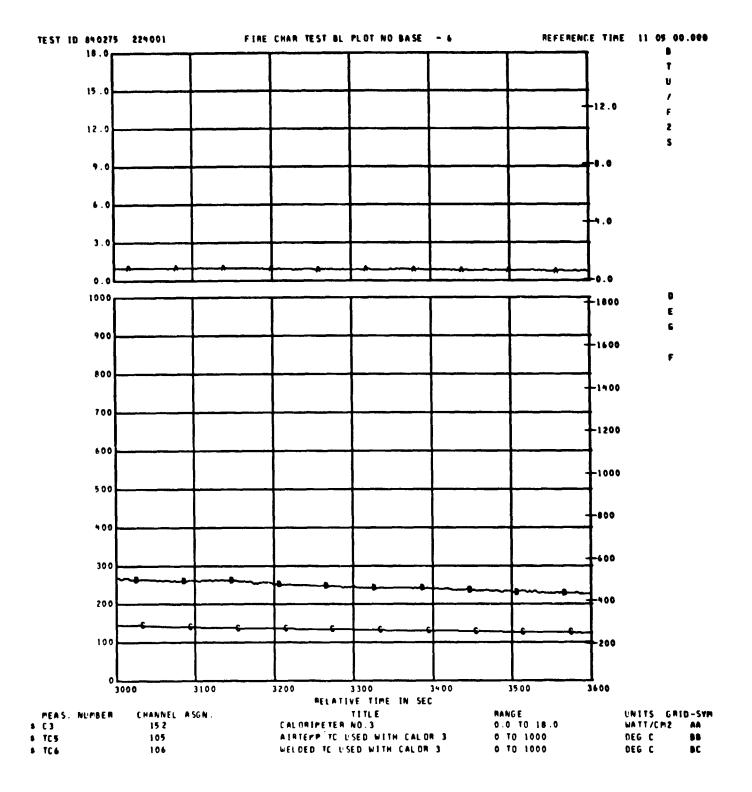


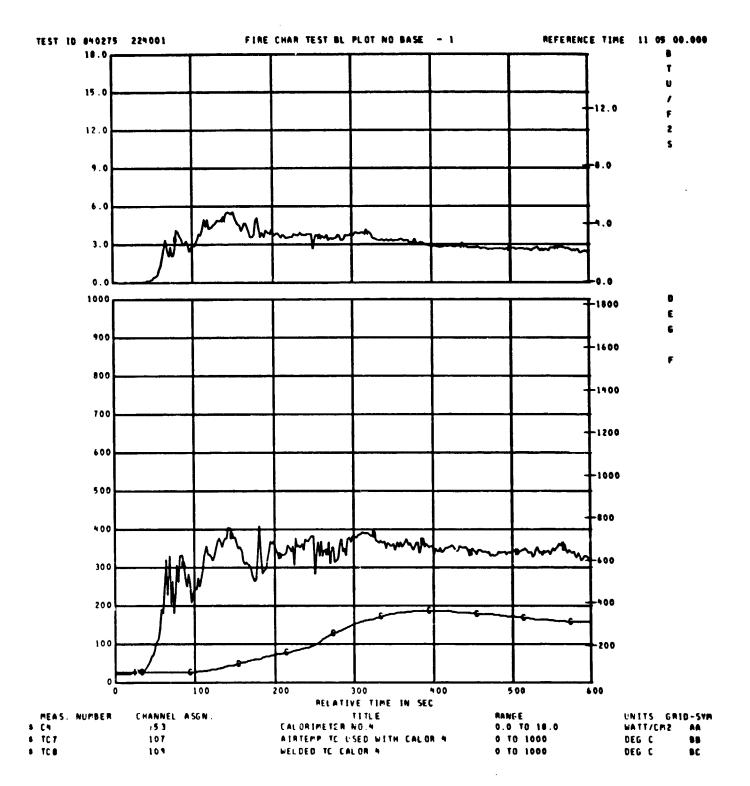


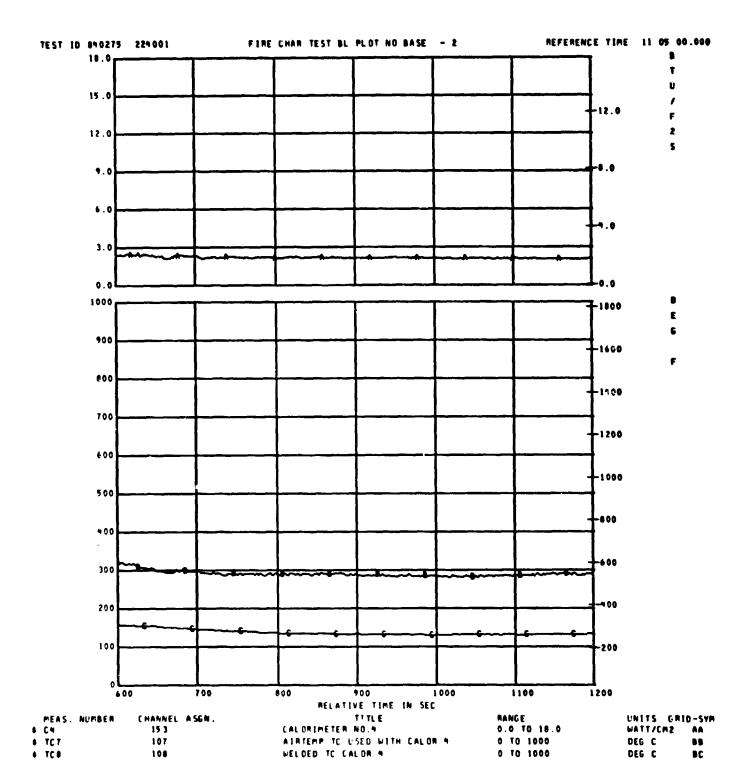


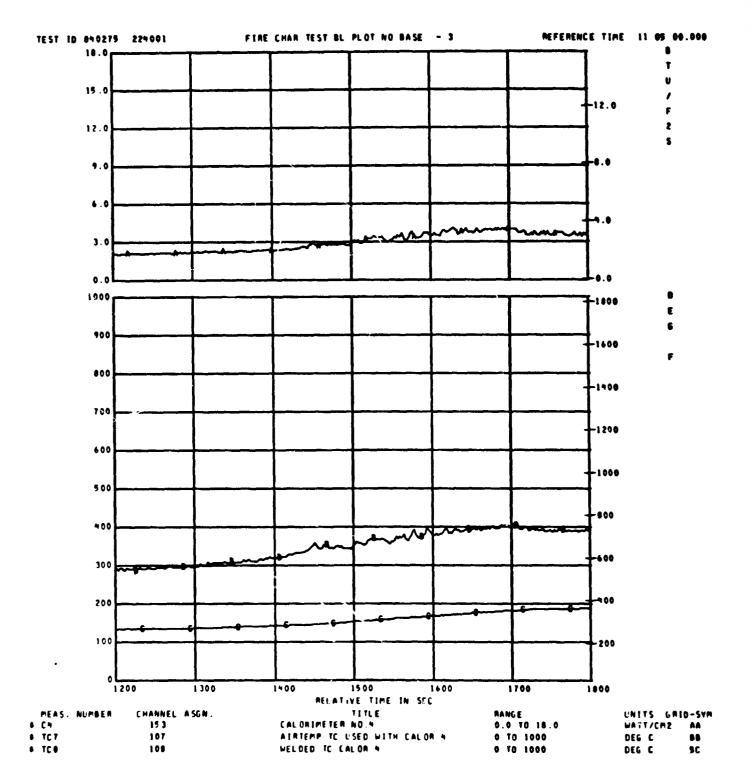


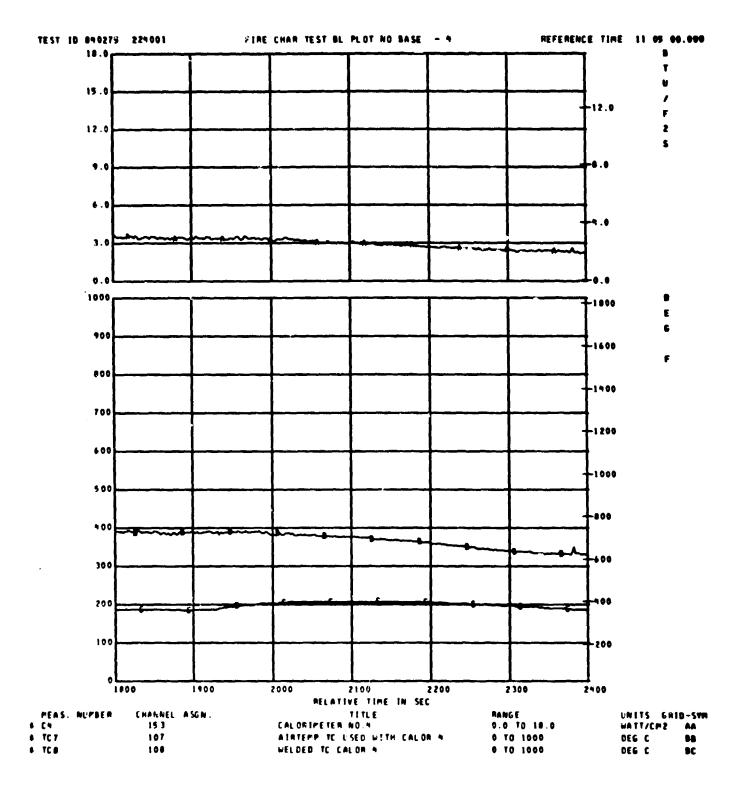


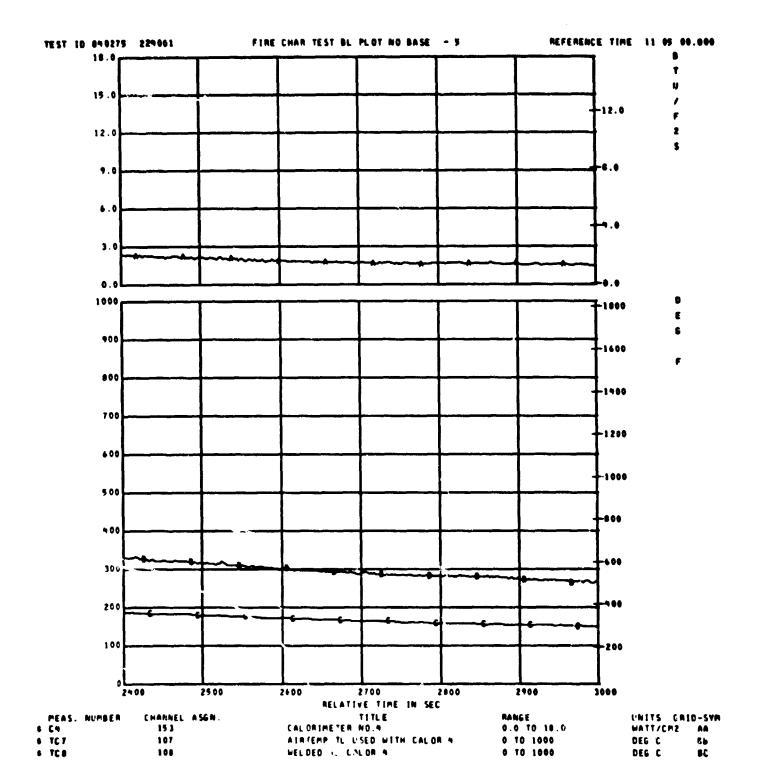


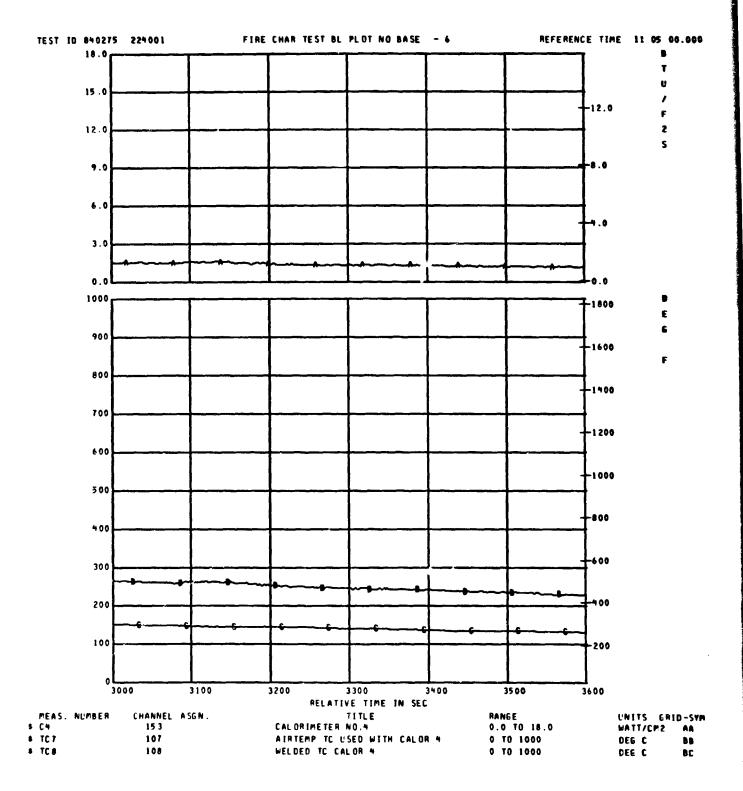


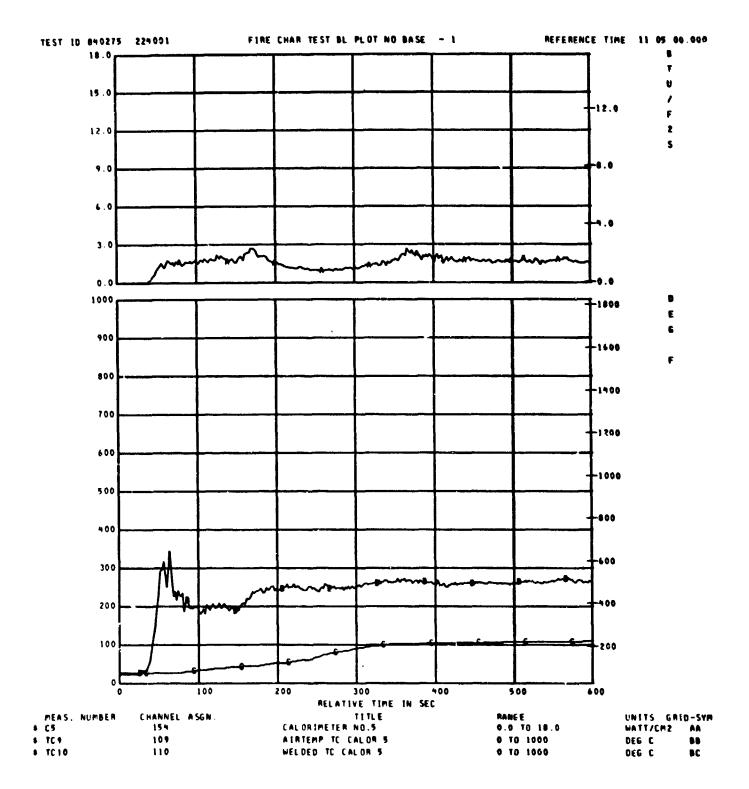


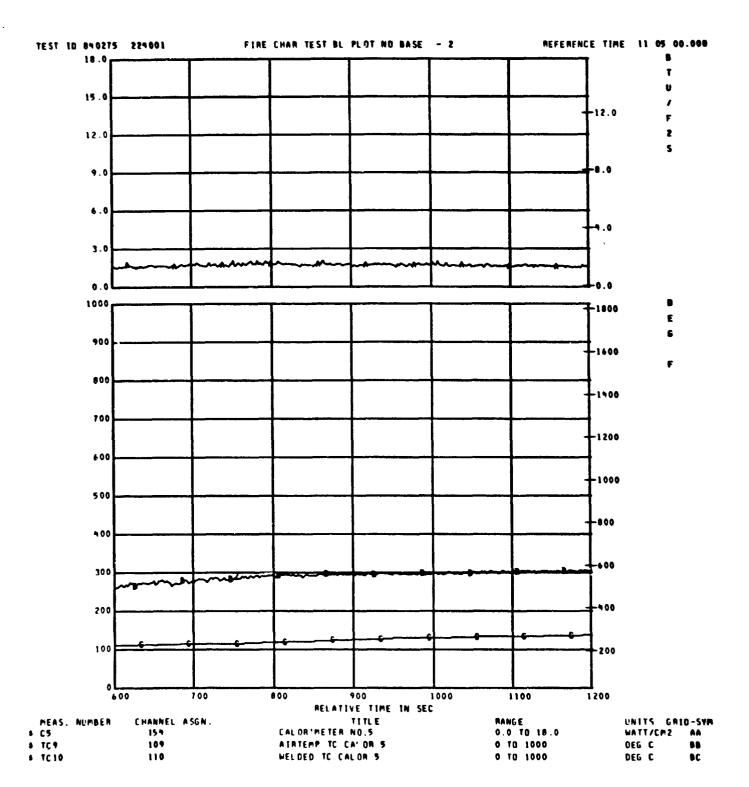


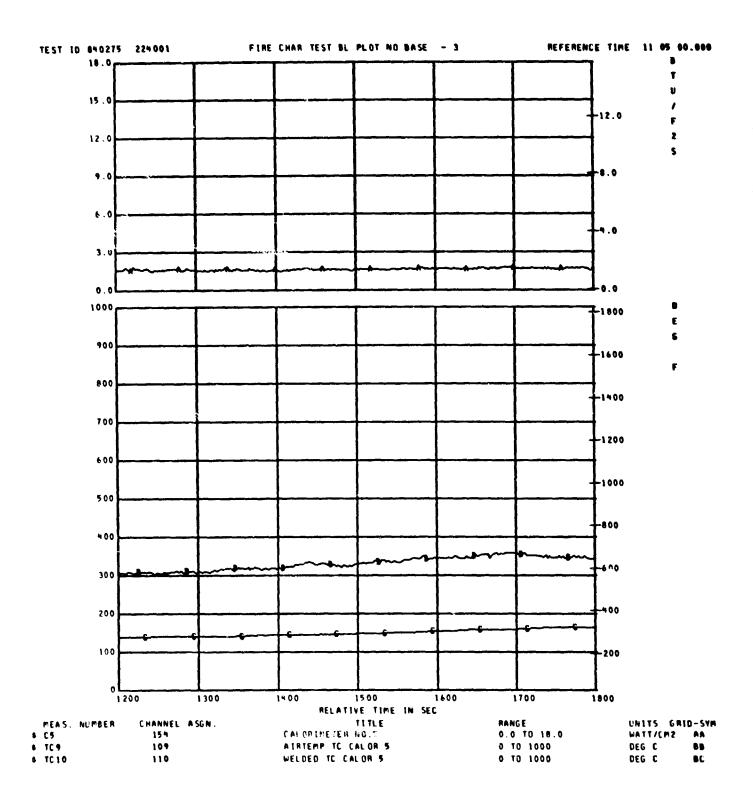


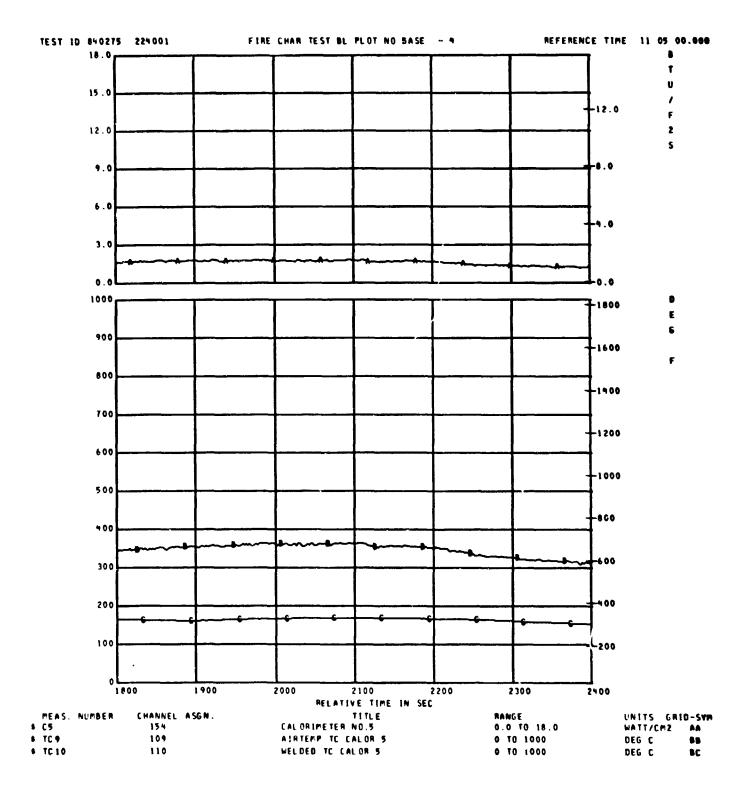


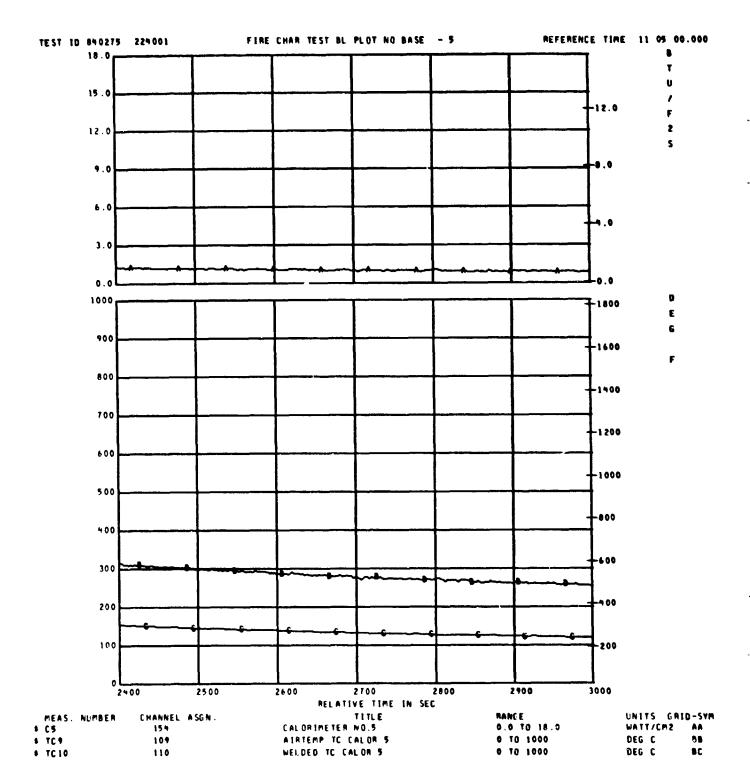


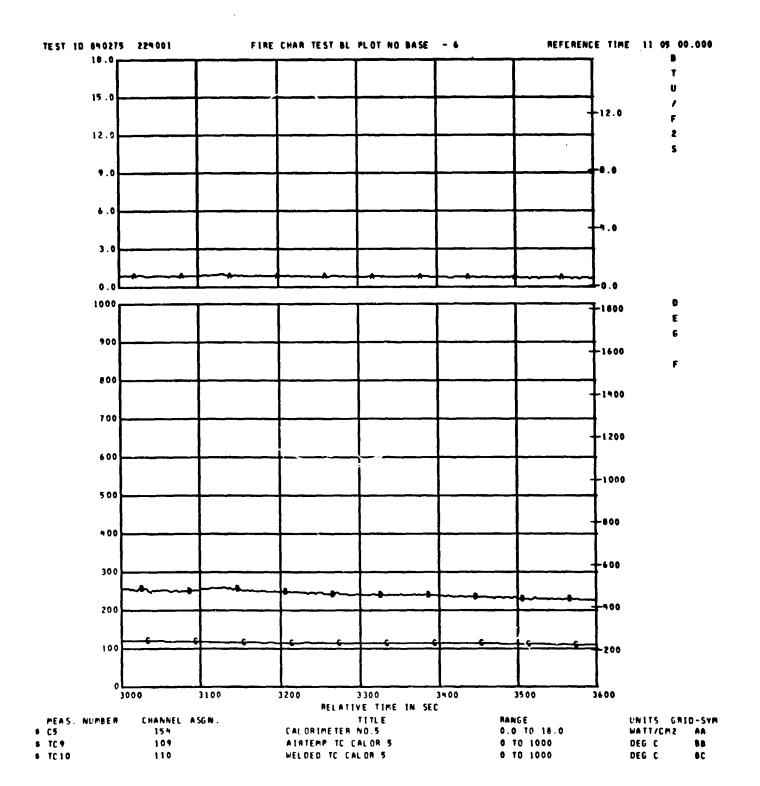






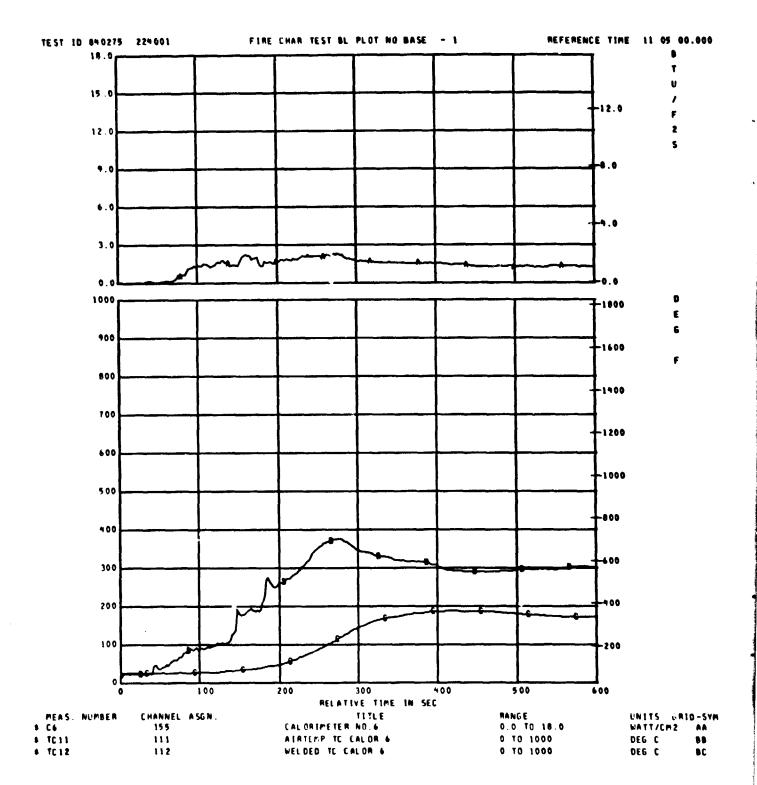


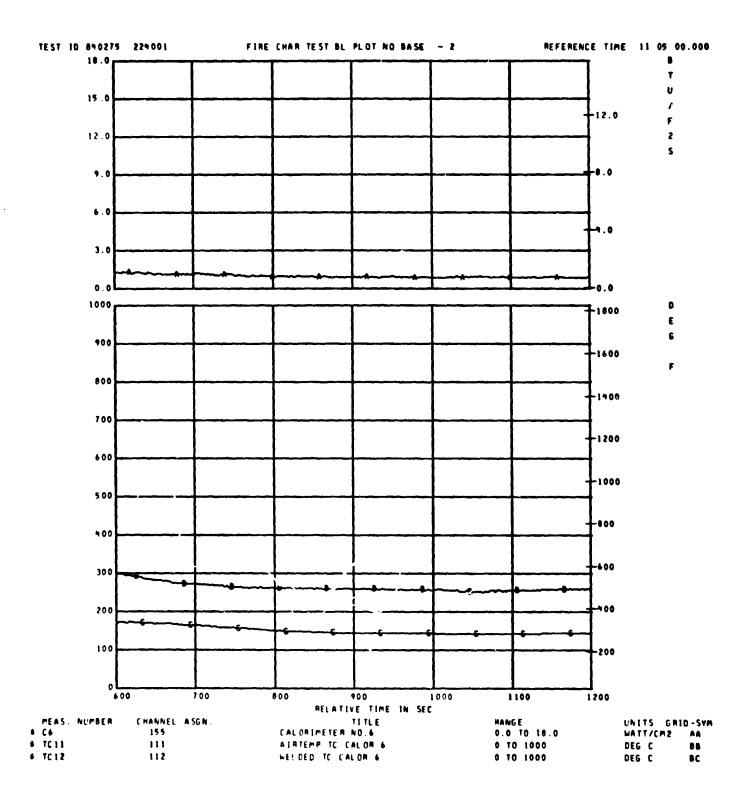


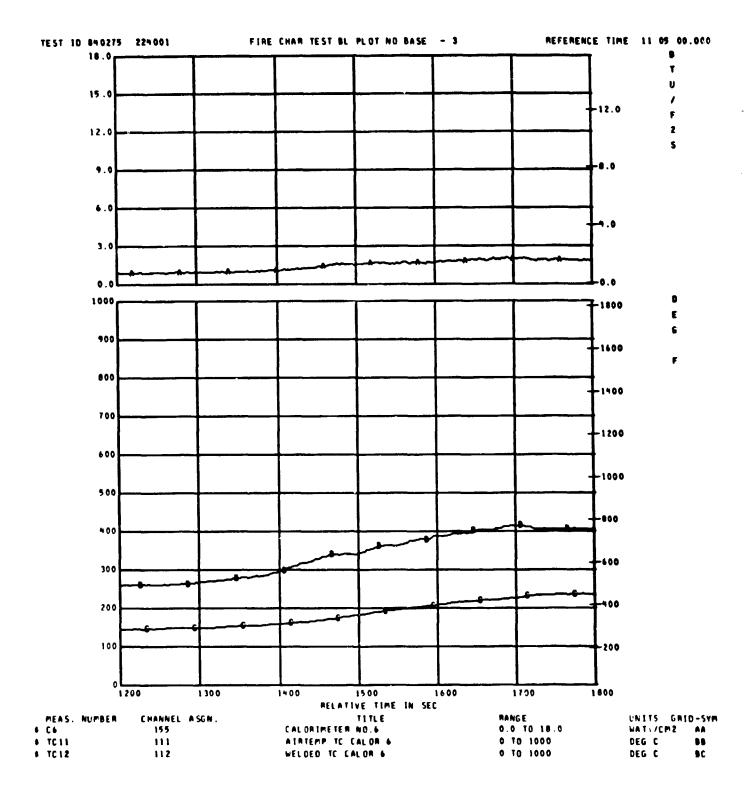


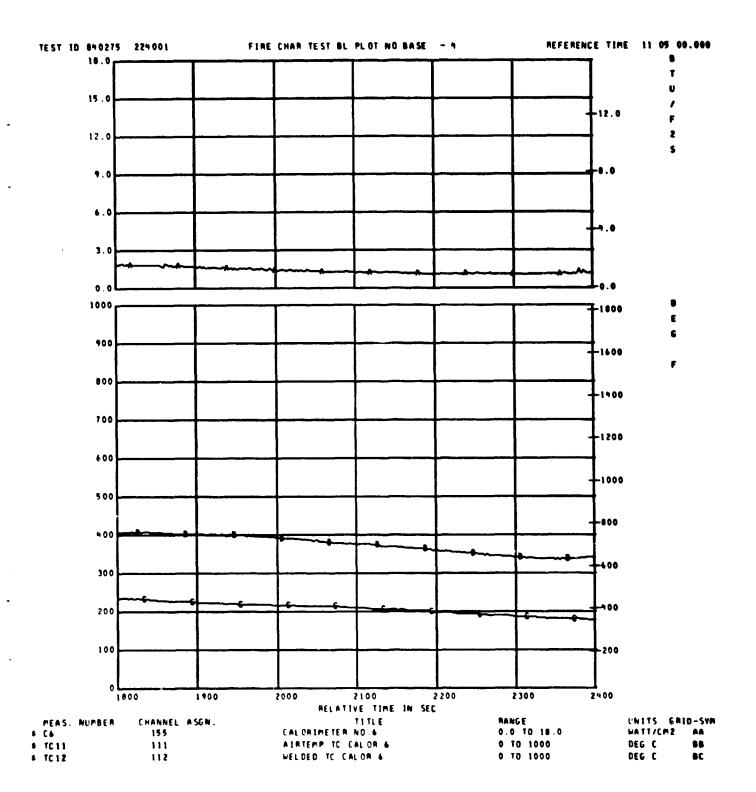
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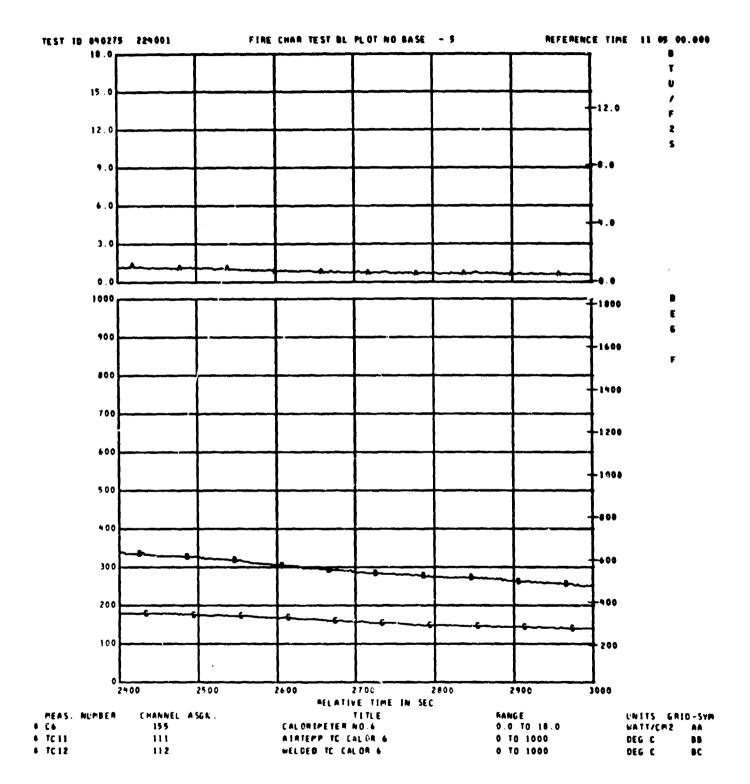
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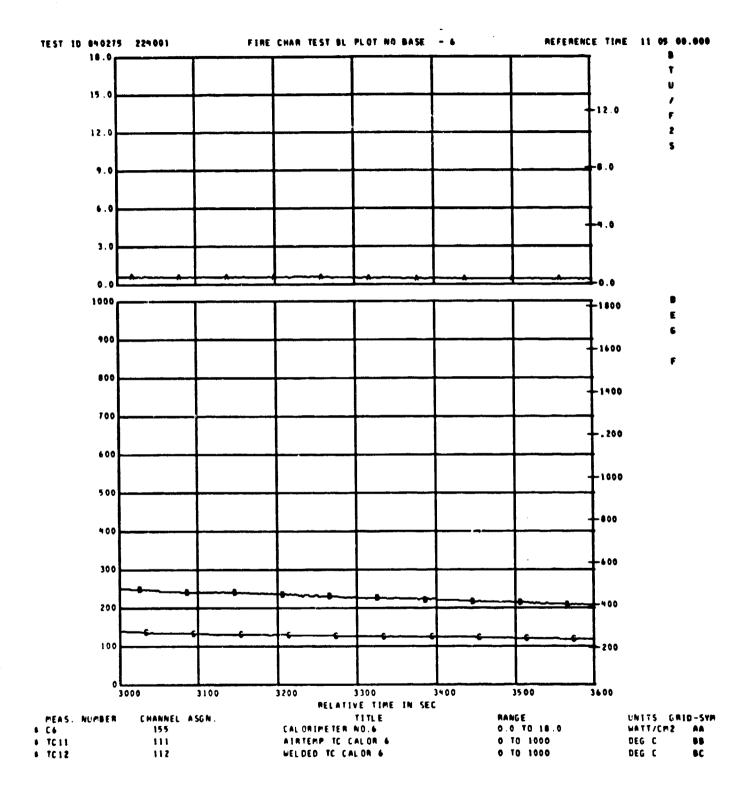


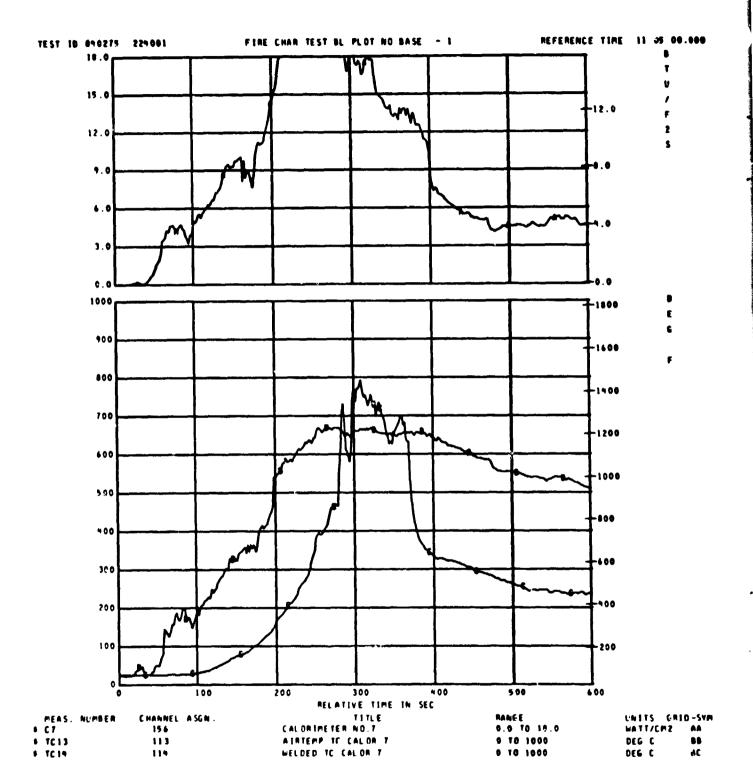


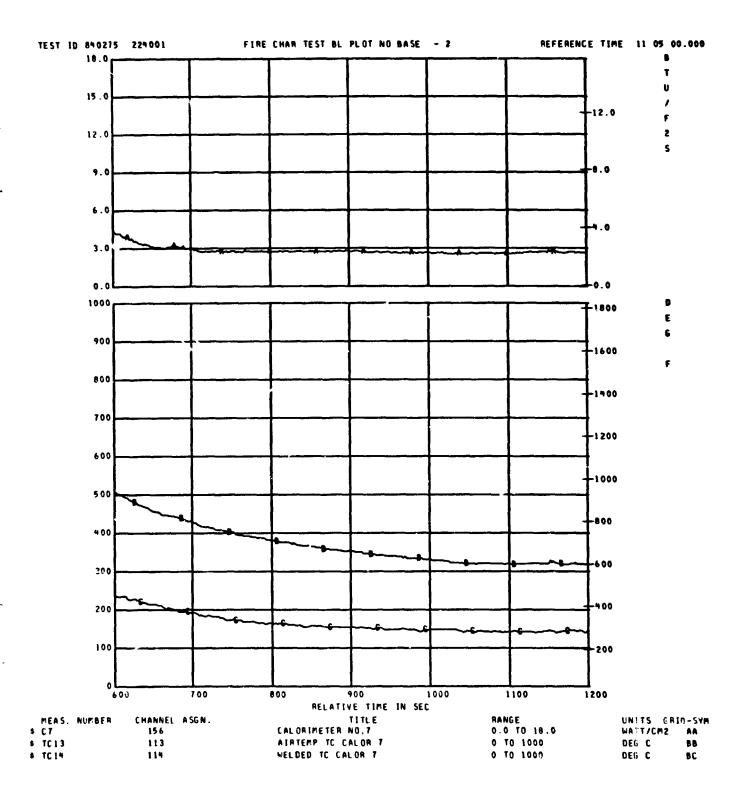


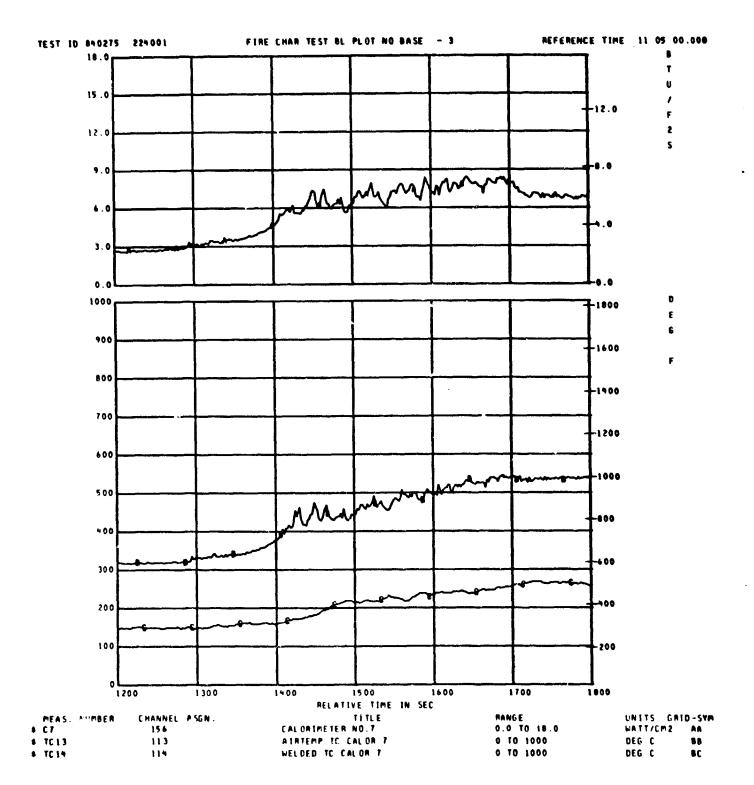


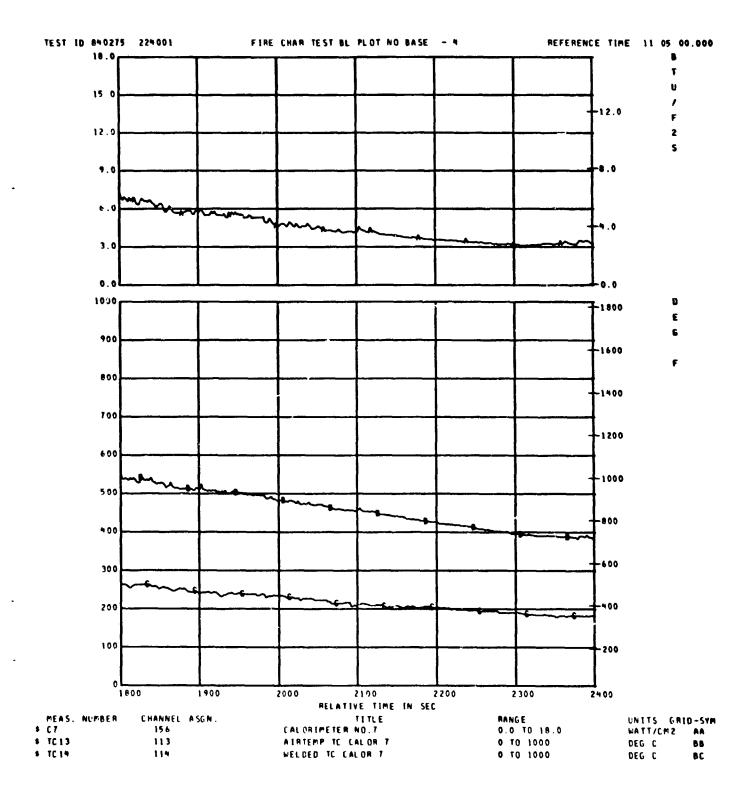


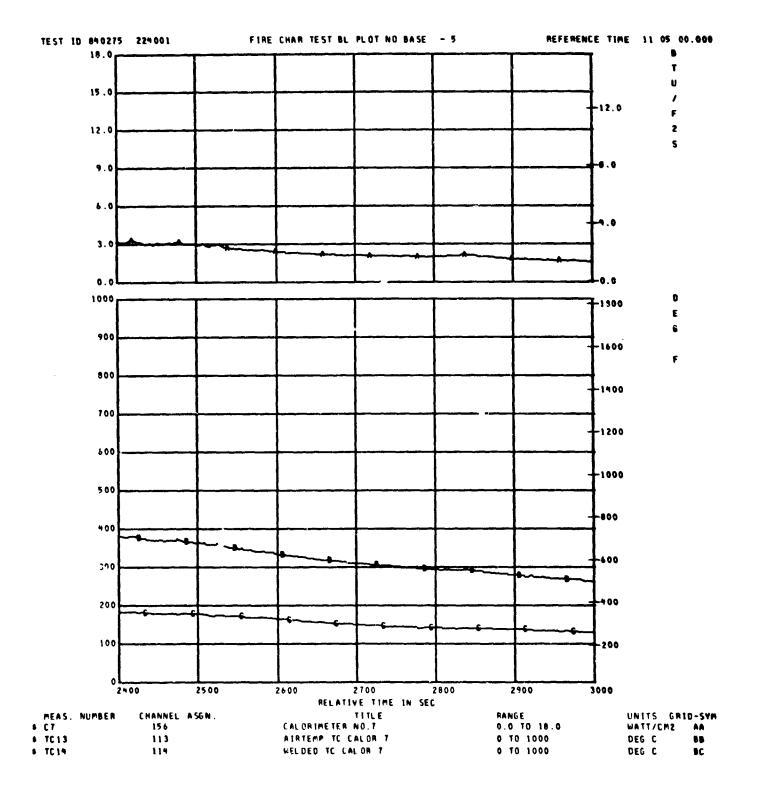


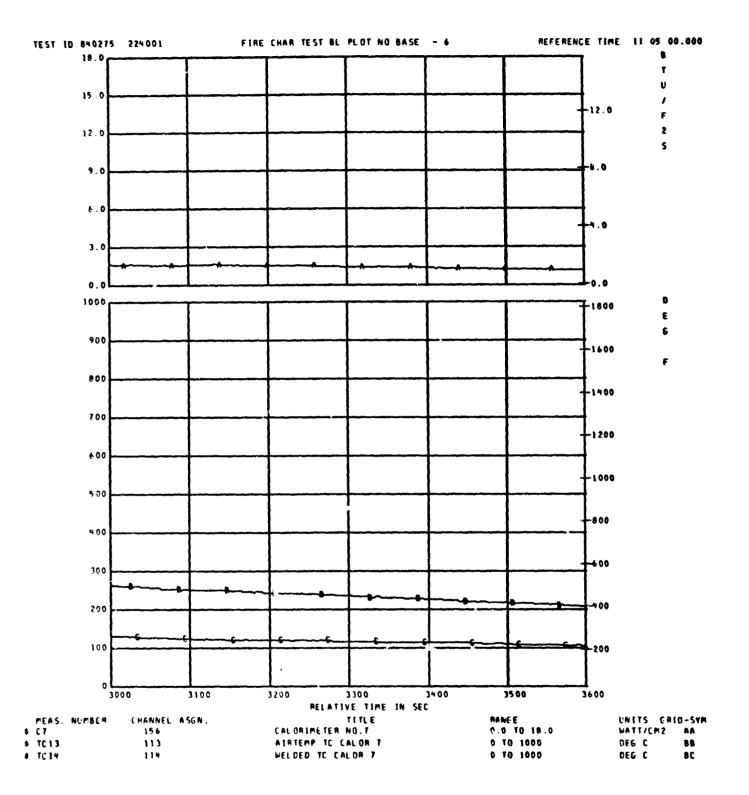




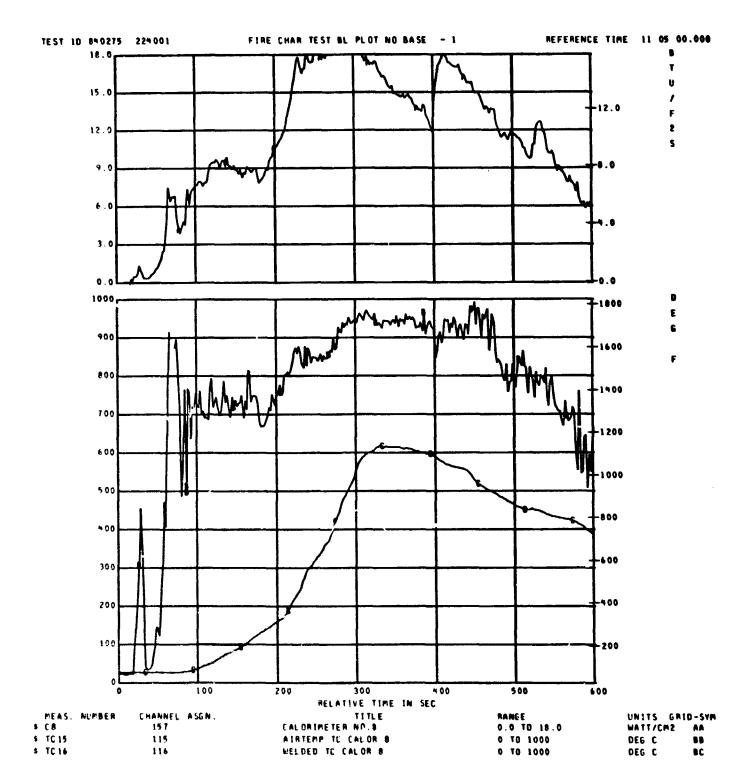


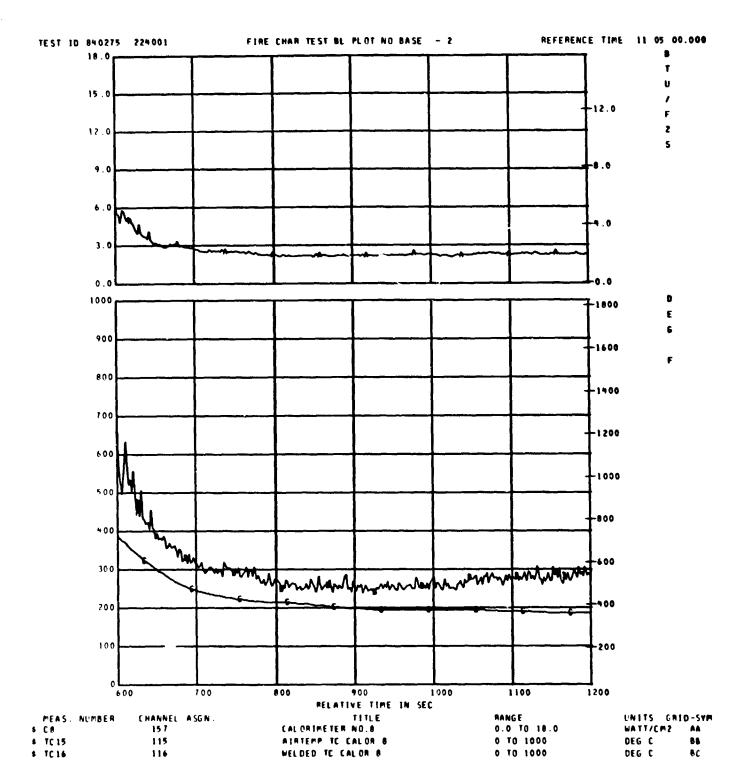


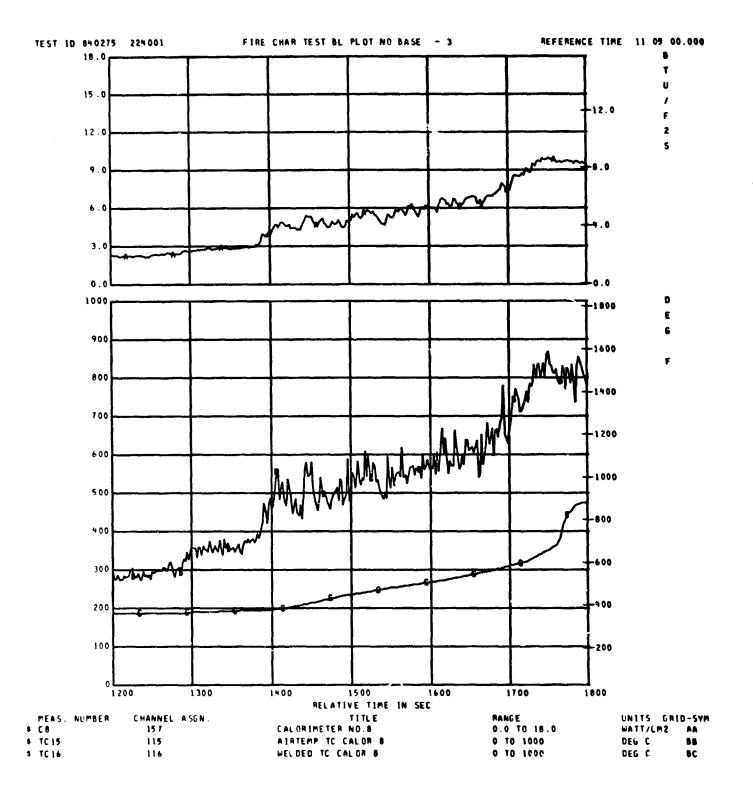


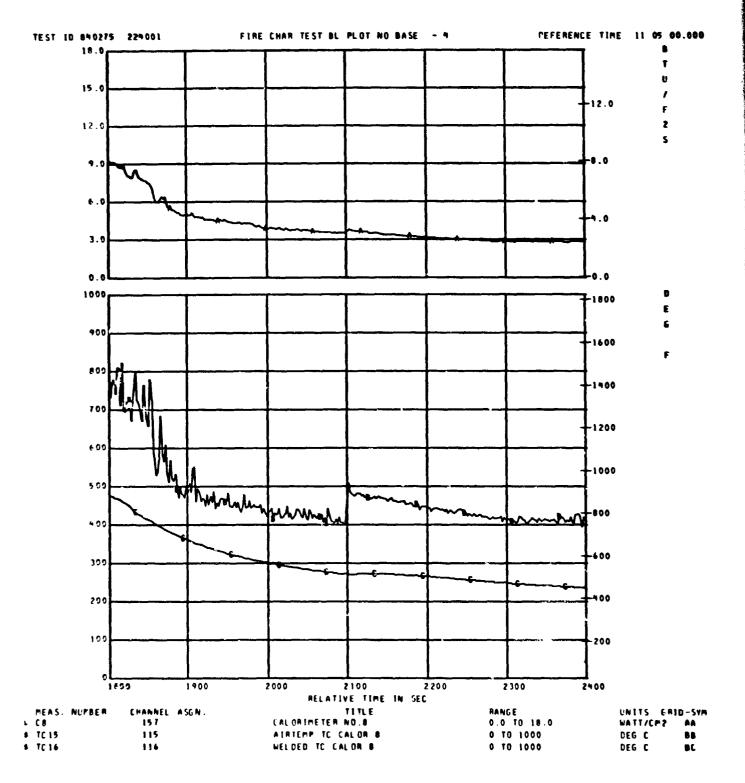


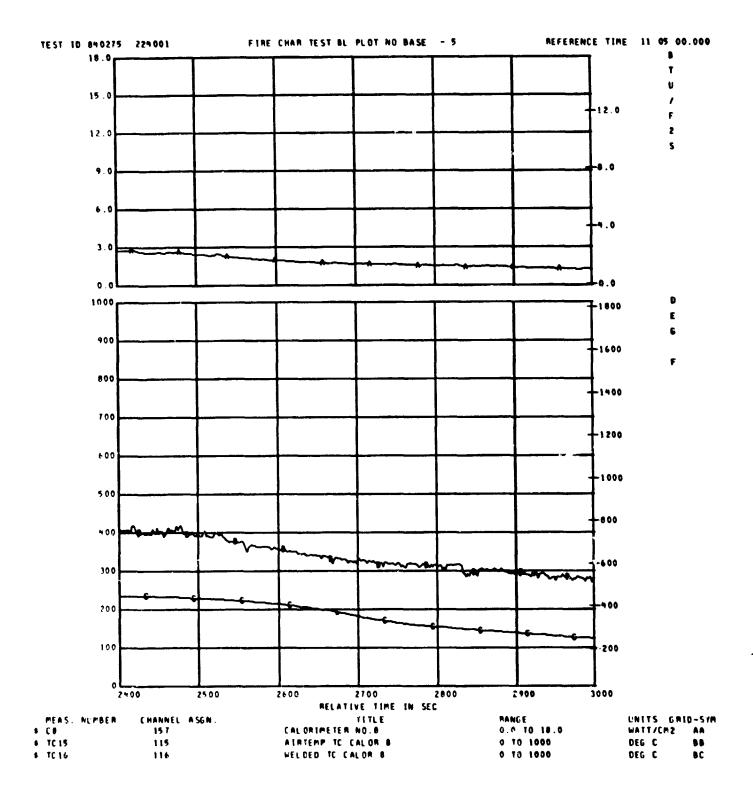
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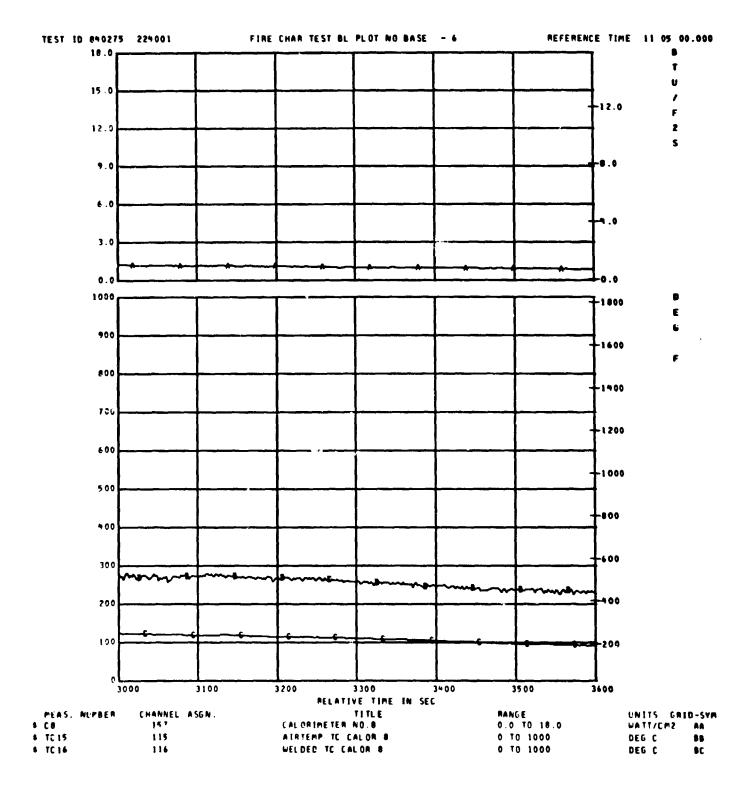


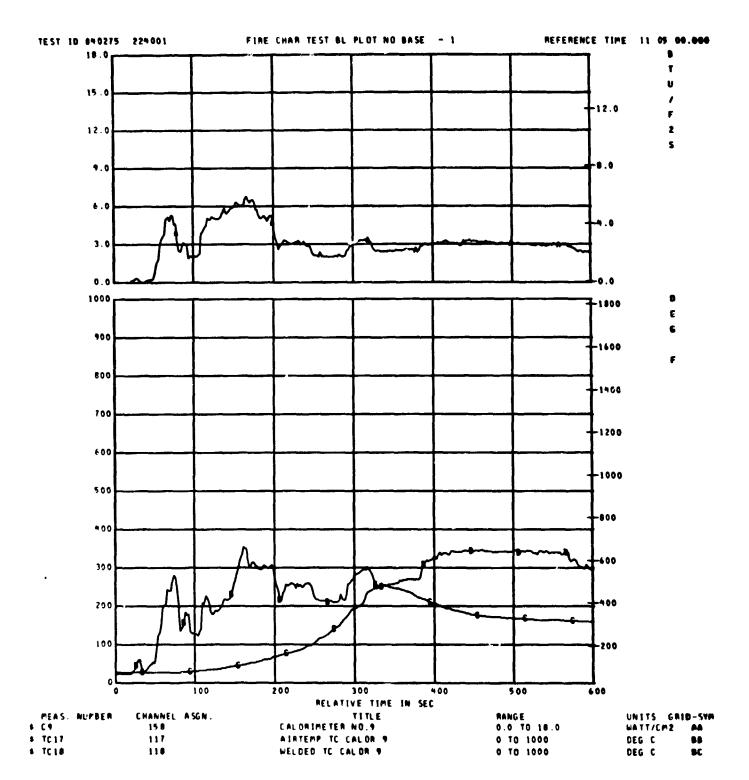


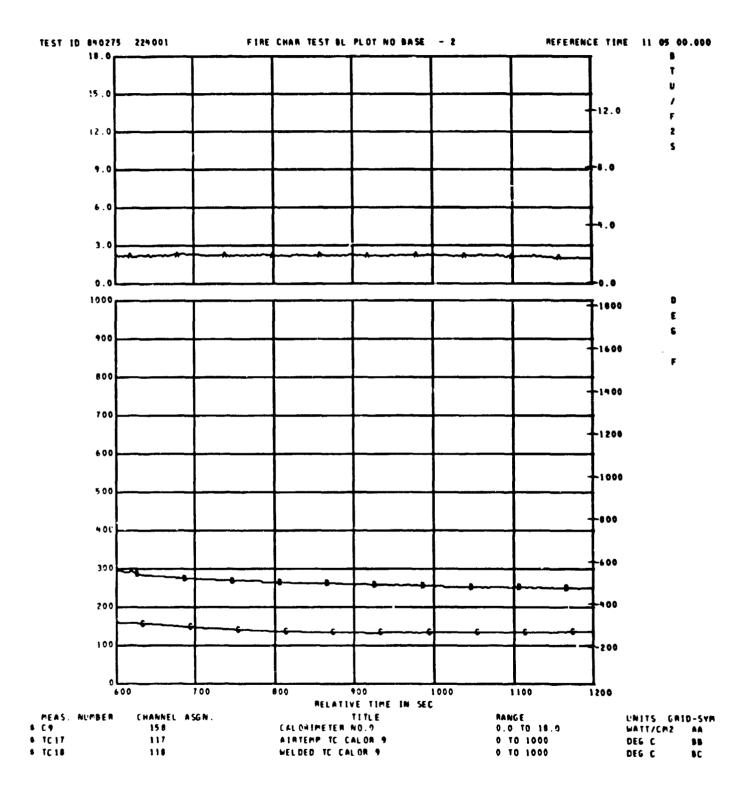


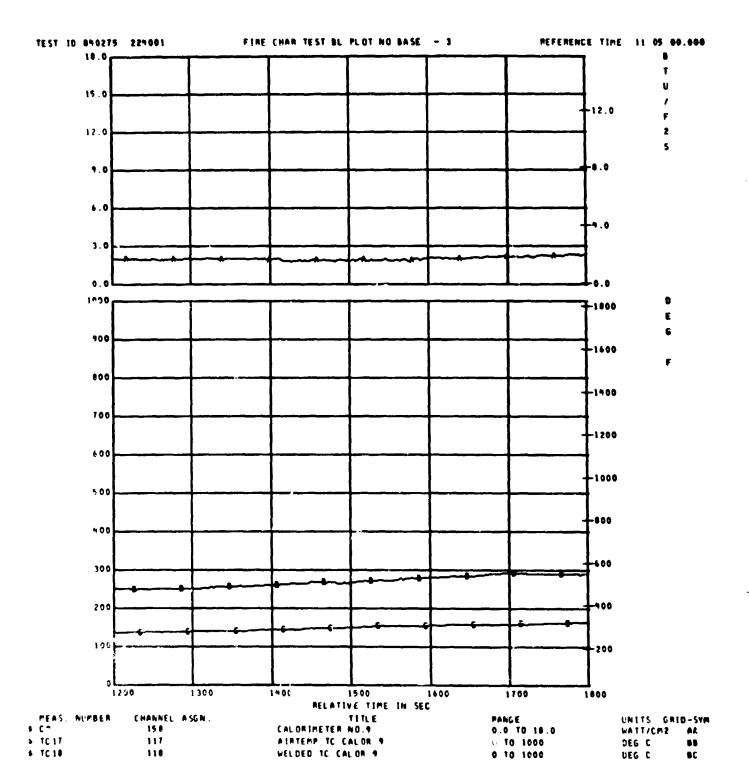


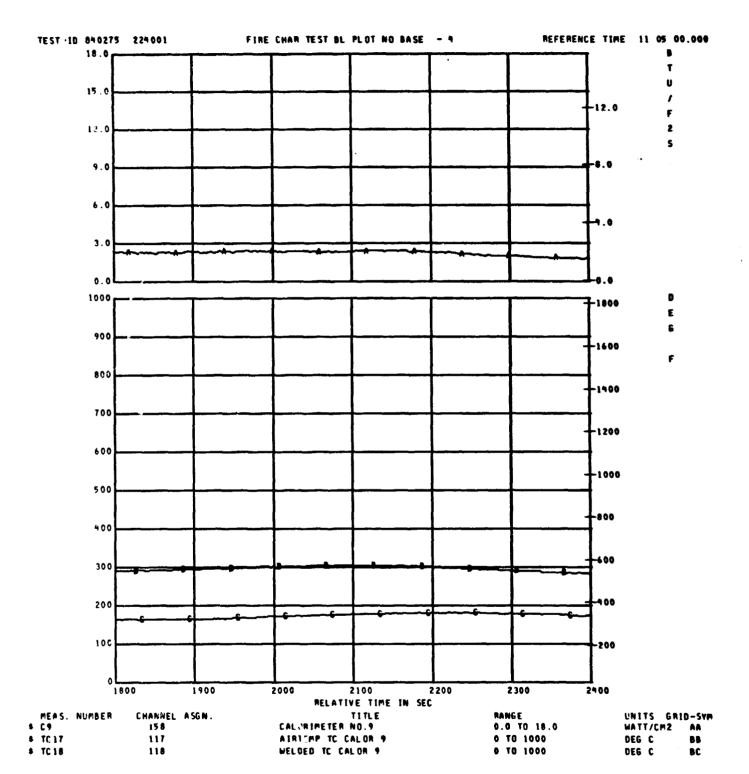












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